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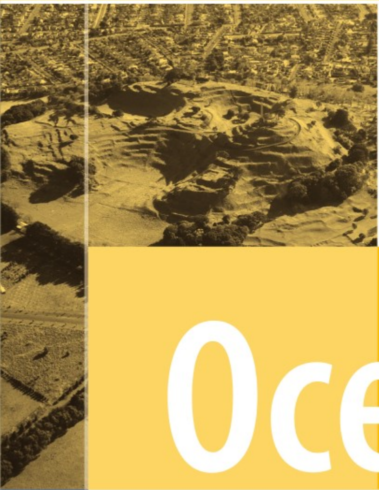

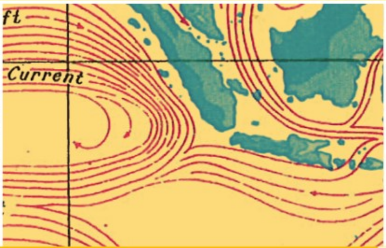

Oceanic

Paths, Sequence, Timing and Range of Prehistoric Migration in the Pacific and Indian Oceans

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Charles E.M. Pearce · Frances M. Pearce

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To our daughters Emma and Ann

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List of Journal Abbreviations

Advances in Geo Ecology Adv Geo Ecol
Annals of Human Biology Ann Hum Biol
American Anthropologist Am Anthropol
American Anthropology Am Anthropol
American Antiquity Am Antiq
American Journal of Human Genetics Am J Hum Genet
American Journal of Physical Anthropology Am J Phys Anthropol
Anthropological Science Anthropol Sci
Antiquity Antiq
Archaeology in New Zealand Archaeol NZ
Archaeology in Oceania Archaeol Ocean
Asian Perspectives Asian Perspect

Bulletin of the American Museum of Natural History Bull Am Mus Nat Hist
Bulletin of the National Museum of New Zealand Bull Natl Mus NZ
Bulletin of the New York Academy of Medicine Bull NY Acad Med

Climate Dynamics Clim Dyn
Current Anthropology Curr Anthropol

Electrophoresis Electrophor
Ethnology Ethnol

Geophysical Research Letters Geophys Res Lett
Globe and Planetary Change Glob Planet Chang

Journal de la Societe des Oceanistes J Soc Ocean
Journal of Archaeology in New Zealand J Archaeol NZ
Journal of Geophysical Research J Geophys Res
Journal of Human Evolution J Hum Evol
Journal of Pacific History J Pac Hist
Journal of Paleoclimatology J Paleoclimatol
Journal of the Royal Society of New Zealand J R Soc NZ

Journal of Scientific Exploration J Sci Explor
Journal of the Polynesian Society J Polyn Soc

Modern Quaternary Research in Southeast Asia Mod Quat Res
Molecular Biology and Evolution Mol Biol Evol

National Genetics and Medicine Nat Genet Med
National Geographic Research Exploration Natl Geogr Res Explor
Nature Nat
New Zealand Archaeological Association Newsletter NZ Archaeol Assoc Newsl
New Zealand Journal of Archaeology NZ J Archaeol
New Zealand Journal of Ecology NZ J Ecol
New Zealand Medical Journal NZ Med J

Oceanic Linguistics Ocean Linguist

Pacific Archaeology Pac Archaeol
PloS Biology PloS Biol
PloS Genetics PloS Genet
Pre-Columbiana Pre-Columb
Proceedings of the National Academy of Science Proc Nat Acad Sci

Quaternary International Quat Int
Quaternary Research Quat Res
Quaternary Research Reviews Quat Res Rev
Quaternary Science Reviews Quat Sci Rev

Radiocarbon Radiocarb
Records of the Auckland Institute and Museum Rec Auckl Inst Mus
Revista de Historia de America Rev Hist Am

Science Sci
Science Progress Sci Prog
Science of Tsunami Hazard Sci Tsunami Hazard
Social Science and Medicine Soc Sci Med

Transactions and Proceedings of the New Zealand Institute Trans Proc NZ Inst
Trends in Ecology and Evolution Trends Ecol Evol
Trends in Genetics Trends Genet

Vistas in Astronomy Vistas Astron

World Archaeology World Archaeol

Part I
Early Exploration Strategies and Migration Paths

Chapter 1
Introduction

Abstract Chapter 1 offers an overview of the central argument of the book: that Spice Island mariners, following three of the four major fast warm currents flowing out of what oceanographers call the West Pacific Warm Pool, were able to traverse vast ocean distances. In two periods, separated by a global cold period between 1000 BC and 400 BC, they followed these currents west to Madagascar and east Africa, north to Japan, Hawaii and America and south to New Zealand. Exploiting powerful WPWP currents made possible a history of exploration and settlement in two oceans pursued over millennia by Spice Island maritime traders and their descendants. This history and its oceanographic base are the primary focus of the book.

Keywords Genetics · Oceanography · Wallacean homeland · Cold adaptation · West Pacific Warm Pool · Consilience of evidence

1.1 Introduction

Oceanic Migration is a study of the last migrations involved in the peopling of the planet: the prehistoric peopling of the Pacific. It is novel in two respects. It uses science and mathematics (much of it drawn from outside the range usually called upon by archaeologists and prehistorians) to significantly expand the research base of Pacific prehistory and cast new light on this final human expansion. It focuses on two undeveloped areas of research: exploring the fundamental roles of oceanography and of global climate change in determining the paths, sequence, timing and range of migrations that settled islands stretching across a quarter of the globe – from Madagascar in the west to Easter Island in the east, from Hawaii in the north to New Zealand in the south.

Though the book belongs centrally to the field of Pacific prehistory, it can also be seen as interdisciplinary (science meets prehistory). A belief in the enabling power of science to initiate advances in other disciplines prompted its writing. In the last decade genetic research has established Wallacea and, within Wallacea, Halmahera, the largest of the Spice Islands, as the ancient Polynesian homeland. This finding

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challenges the accepted paradigm of a Taiwanese origin for the Polynesian peoples. Initially we were tempted by the challenge of rewriting Polynesian prehistory with a Spice Island base. Taking on this challenge, however, led us on a journey of discovery scarcely imagined at the outset.

In this chapter we can only sketch the central argument of the book. Discussion of the existing literature and complex substantiation of our claims is provided in the 20 chapters that follow. Because our approach is new and often depends on areas of science that may be unfamiliar to some readers, we have sought in the course of the book to provide substantiation in a systematic way, moving chapter by chapter from one scientific or historical focus to the next. Substantiation is cumulative and complex. It draws on insights from fields as diverse as oceanography, traditional histories, physiology, genetics, geology and vulcanology, ship hydrodynamics, global climate history and palaeodemography.

Conceiving of Wallacea as the ancient Polynesian homeland has immediate implications. In Wallacea lie the Spice Island archipelago and the island of Sulawesi. This ocean area has significance geologically and for the history of evolution: within it also lies Wallace's Line, the deep ocean trench that separates Asia from the Pacific, an ocean barrier ensuring the independent evolution of species in the two regions. The pivotal position of Wallacea between these two regions made it a natural place for the domestication of plants and animals drawn from both regions, for their maritime dispersal to Island Southeast Asia and beyond and for their ultimate translocation east into the Pacific and as far west as Africa.

Halmahera is the largest of the Spice Islands. In contexts involving foreign exploitation of spices, the term Spice Islands sometimes refers only to the five tiny clove-growing islands that lie off the western coast of Halmahera. We use the term to refer to the whole Spice Island archipelago, an archipelago of a thousand islands, its islands from their earliest occupation unusually interdependent and their histories interconnected.

Contemplating a 40,000-year-long indigenous maritime history for the ancestors of the Polynesians in the Spice Islands, we realized that the first 30,000 years of this history would have been played out during the last Ice Age. And that where today we see the Spice Islands as lying at the edge of the 17,000 islands of Island Southeast Asia, for most of their inhabited history the Spice Islands formed a singular archipelago poised between the two ancient continents of Sundaland and Sahul. (It was only 7,500 years ago, after the last Ice Age flood drowned Sundaland, that Island Southeast Asia was created from the mountainous regions and uplands of this drowned continent.) Exploring the long indigenous maritime history of the ancient Spice Island archipelago not only led us to realize the genetic and maritime implications of a Spice Island base for Polynesian prehistory, but also and more importantly led us to consider the oceanographic implications of the Spice Islands as a base for oceanic migration and for transoceanic trading in two oceans.

In particular it led us to study the oceanographic and volcanic history of what oceanographers call the West Pacific Warm Pool. For even during the last Ice Age the northern Spice Islands lay within or close to its borders. Understanding the history of the West Pacific Warm Pool we found was necessary not only for an adequate understanding of the maritime history of the Spice Islands but more vitally for understanding the choice of migration paths and the sequence and timing of Spice Island-based migrations. For we came to see these migrations as forming part of a long history of exploration and settlement in both the Pacific and Indian Oceans, initiated and pursued over millennia by Spice Island mariners and traders and their descendants exploiting the power and warmth of West Pacific Warm Pool currents.

1.2 Genetic Evidence for a Spice Island Polynesian Homeland

For the last 50 years Taiwan has been accepted by most archaeologists and prehistorians as the homeland of the so-called Lapita peoples, ancestors of the Polynesians. But recent genetic evidence now challenges accepted paradigms based on the late arrival in Near Oceania of Chinese agriculturalists migrating via Taiwan, Luzon and the Philippines. These Chinese agriculturalists are said to have arrived in the Bismarck and Solomon archipelagoes 3,600 years ago, rapidly expanding from there into Remote Oceania and Western Polynesia. After a hiatus variously estimated to be from 500 to 1,500 years their descendants are seen as moving on to colonize Eastern Polynesia.

In the past seven years Stephen Oppenheimer, Oppenheimer and Richards and Trejaut et al. have provided genetic evidence challenging the theory of a Taiwanese origin for the Polynesian peoples. Study of coalescence times for three mutations, which differentiate Spice Islanders, coastal Papuans and Polynesians from populations in Taiwan, Luzon and the Philippines, has provided strong evidence for a Polynesian homeland in Wallacea. All three differentiating mutations have been sourced to the region:

(i) the fourth polymorphism of the “Polynesian motif” [1];
(ii) the mitochondrial mutation at np 14022 which differentiates the later haplogroup B4a1a1 (common to Spice Islanders, coastal Papuans and Polynesians) from the older haplogroup B4a1a (found in the Philippines, Luzon and amongst indigenous Austronesian-speaking Taiwanese tribes) [2]; and
(iii) the Y chromosome mutation M38 [3].

The coalescence times for these mutations jointly suggest that the most recent genetic interactions between the two groups of populations – Spice Islanders, coastal Papuans and Polynesians on the one hand and populations in Taiwan, Luzon and the Philippines on the other (as represented in modern all-female and all-male lines) – may have occurred about 11,500 years ago. That is, 8,000 years before the so-called Express Train to Polynesia (according to the commonly accepted paradigm carrying Chinese farmers from Taiwan) could have arrived in Near Oceania. Recent genetic analysis involving full genome sequencing of the mitochondrial haplogroup E, moreover, suggests that the direction of ancient gene flow was from Island Southeast Asia to Taiwan rather than from Taiwan to Island Southeast Asia [4].

In 2004 strong evidence not just for a Wallacean but more specifically for a Spice Island origin for the Polynesian peoples was provided by the innovative work of archaeobiologists Elizabeth Matisoo-Smith and J.H. Robins who studied the migration history of the Pacific rat which was carried into the Pacific by Polynesians as a food animal. Constructing a neighbour-joining tree, Matisoo-Smith and Robins traced both of the haplogroups that are found in the Pacific specifically to Halmahera, establishing this island as the homeland for the Pacific rat and, by implication, for the people who carried it into the Pacific [5]. In 2005 the case for a Lapita and Polynesian homeland in the Spice Islands was strengthened by genetic evidence from a major worldwide study of centres of pig domestication which established that the pig carried into the Pacific by the Lapita and Polynesian peoples belonged to a separate clade from the Taiwanese pig [6]. The authors suggested that the Polynesian pig was probably indigenous to the Spice Islands or Wallacea. In 2007 further work in this area found the Polynesian pig to be indigenous to peninsular Southeast Asia but charted its introduction to the Moluccas (the Spice Islands), supporting a Spice Island base for its introduction into the Pacific [7].

1.3 Cold Adaptation

Additional genetic support for a Spice Island origin for the so-called Lapita peoples and their Polynesian descendants rests in evidence that, as Philip Houghton shows, present-day Polynesians possess the highest level of cold resistance by any people on the planet [8] although most Polynesians live in a tropical region and Matisoo-Smith and Robins' research shows they descended from people who lived on the equator (the equator actually passes through Halmahera). As non-sex-linked genes are involved in determining cold adaptation and these genes are estimated to mutate at only a tenth of the rate of mitochondrial DNA [9], tens of thousands of years of exposure to cold may well have been needed for the evolution of such a degree of cold resistance.

Houghton's research [10], one of the evidence bases we call on, is discussed in detail in Chapter 2. It establishes as a fundamental premise that without high levels of genetic cold resistance and famine resistance the Lapita peoples and their Polynesian descendants would not have been physiologically capable of exploring and colonizing the Pacific.

But where Houghton argues for a late fast evolution of cold resistance in Island Melanesia en route to Western Polynesia, we see Polynesian cold resistance as arising, rather, from a 40,000-year-long maritime history in the Spice Islands, the first 30,000 years of this history played out on sailing rafts in the last Ice Age. We see the evolution of the Spice Islanders' cold resistance as being correlated, moreover, with the economic and maritime expansions that shaped their history as they moved from local to regional to international spice trading.

1.4 A New Focus

Oceanic Migration charts new territory by exploring in some depth the historical, oceanographic, genetic and maritime implications of a Spice Island origin for the so-called Lapita peoples and for their Polynesian descendants. For those living on Halmahera and in the northern islands of the Spice Island archipelago, sailing activities, even during the last Ice Age, would have been carried out on the borders of or just within the West Pacific Warm Pool. Its high sea surface temperatures would have provided Spice Island mariners with significant protection against hypothermia. Indeed the West Pacific Warm Pool might be thought of as an Ice Age maritime refuge, its seasonally shifting boundaries determining trade paths and seasonal trading possibilities during the Ice Age.

But of greater significance and central to this book was our realization that in the Holocene (the warm climate period that followed the Ice Age about 11,000 years ago) the West Pacific Warm Pool could have played an even greater role in shaping Spice Island maritime history. We realized that the oceanographic and volcanic history of the West Pacific Warm Pool, following the last Ice Age flood 7,500 years ago, may have determined the earliest trading and migration paths of the Spice Island mariners as they moved out from their maritime Ice Age refuge. Specifically the location of the Spice Islands on the borders of the West Pacific Warm Pool suggested the possibility that Spice Island mariners as explorers and traders may have followed major fast warm currents flowing out from the West Pacific Warm Pool into the Pacific and Indian Oceans.

In the last 50 years archaeological research has largely focussed on the so-called Lapita peoples, on the Lapita cultural complex and on unravelling the complexities of the late west–east colonization of Eastern Polynesia from Western Polynesia. These have been obvious foci for research for archaeologists and prehistorians since the first discovery of ceramic pots at Lapita in New Caledonia in 1952. Our focus is very different. Exploring the implications of a Pacific prehistory with a Spice Island base and a very considerable time depth has led to a new assessment of factors that may have determined not only the genetic profile of Polynesians but also the earliest sailing and exploration strategies, and associated trading and migration paths and migration sequence.

Oceanic Migration is the first prehistory of the Pacific to be written with the Spice Islands seen not only as an initial but also as a later major base for expansion into the Pacific and Indian Oceans. This contrasts with the long-held belief that Taiwan, Near Oceania and then Western Polynesia were the consecutive and only bases for expansion into the Pacific. A very different understanding of the earliest exploration and migration paths follows from our adoption of this new focus. We are able, for example, to tie the main Spice Island exploration, trading and migration paths to three of the four major currents flowing through and out of the West Pacific Warm Pool, to show the economic motivation of spice trading as persistently driving Spice Island maritime expansions following these currents and to tie the technological developments needed to empower successive expansions to specific changes in oceanographic conditions within the West Pacific Warm Pool.

1.5 Some of the Implications of a Spice Island-Based Polynesian Prehistory

Because we focus on new areas of interest, to some extent our work complements rather than contradicts existing research. Prehistorians in the last 50 years have focussed on the difficulties of late west–east colonization of Eastern Polynesia from Western Polynesia against the trade winds and currents of the southern Pacific. With a Spice Island base of expansion and an earlier time frame, we focus on completely different exploration and migration paths. We consider the very different exploration and sailing strategies involved in following three of the major fast warm West Pacific Warm Pool currents into colder oceans and in exploiting knowledge of the predictable patterning of ocean currents (dictated by the Coriolis effect) that allow the currents themselves to lead explorers to new lands and to guide them home again. Our research, in other words, challenges the primacy of the later west–east settlement of the Eastern Polynesia from Western Polynesia but not the history or processes involved in that settlement.

Most prehistorians see Hawaii and New Zealand as Eastern Polynesian outliers, settled late from Eastern Polynesia. Most regard them as the last lands in the Pacific to be colonized. Here our views diverge significantly. For we argue that Spice Island explorers and colonizers, following major currents flowing out of the West Pacific Warm Pool, discovered and colonized Hawaii and New Zealand long before the settlement of Eastern Polynesia. We show that they did so using migration paths described in oral traditions: following the East Australian Current flowing out of the West Pacific Warm Pool south to New Zealand and following the Kuro Shio Current flowing through the West Pacific Warm Pool north to Japan and then east through the northern Pacific to Hawaii. The claim that Hawaii and New Zealand were discovered and colonized before the settlement of Eastern Polynesia is not a claim we make lightly. We devote a 100 pages in Part II to its substantiation.

Our claim for an early first settlement of New Zealand, of course, involves us in controversy. It draws us into what has been described as a persisting "unresolved polarized debate about the time of initial human colonization" for New Zealand [11]. Our study of the oceanographic background to Polynesian voyaging and the central paradigm we define provide a new context for considering the likelihood that Spice Island mariners followed a West Pacific Warm Pool current, the East Australian Current, to New Zealand, as traditional sources record. (See Chapter 16.) There is evidence that Spice Island mariners followed the Kuro Shio Current from the Spice Islands to southern California before 1000 BC. The possibility that Spice Island mariners also followed another West Pacific Warm Pool current over a shorter route to reach New Zealand before 1000 BC is seriously considered. Our contribution to this heated and unresolved debate is twofold. We provide an oceanographic context in which the likelihood of an early first settlement of New Zealand can be considered and we present new evidence for such a settlement from palaeodemography and global climate history.

Our case for early first settlement of New Zealand rests centrally on a demonstration of the demographic implausibility of a late settlement in the context of the population numbers needed for the building and defence of Maori Little Ice Age hill-forts Maori pa (hill-forts) (pa). In Part II we set out to establish a mathematically robust palaeodemography for New Zealand which is compatible with estimates from field archaeology, compatible with evidence from a revised analysis of skeletal material [12], and compatible with evidence for climate-driven population losses worldwide during this period.

Also we demonstrate a powerful new approach capable of removing uncertainties about New Zealand's first settlement. A power law analysis of the rank size distribution of New Zealand pa makes it possible to estimate the founder population at first settlement, to provide an estimate for the likely date of the first settlement itself, to estimate an average population growth rate from first settlement to AD 1445, and to estimate the population of the North Island at the beginning of the Little Ice Age. In the light of the demographic analysis of Part II, it is possible to show the implausibility of a 12th or 13th century first settlement date for New Zealand, which requires for its substantiation consistently maintained high population growth rates throughout the Little Ice Age. We show that a late first settlement is incompatible with evidence from skeletal analysis for very severe population decline rates in this period, with the high population capacity of New Zealand pa and with an oral history that records extensive earlier migration.

In Part III we sketch a chronology for Polynesian history through an analysis of genealogies in the light of El Niño low Nile flood proxy data. Statistical analysis of genealogies relating to the *Heke*, the last migration to reach New Zealand from Eastern Polynesia in the Medieval Climatic Optimum, enables us to establish the historicity of this event. A solar eclipse and El Niño data provides a likely dating estimate.

Late 19th and early 20th century prehistorians of European descent sought to generate a western chronology by creating a synthesis of the oral traditions they had so carefully recorded. In Part III we sketch a chronology for Maori and Polynesian prehistory by moving outside the traditions themselves to explore the interface between significant events recorded in tradition and available scientific means for calibrating those events in terms of a western chronology. We have called on the two most obvious means for achieving this: solar eclipses and high-resolution climate proxy data. Even a few instances in which the dating of events recorded in tradition can be established with certainty can create chronological markers Chronological marker strong enough to illuminate prized genealogies that in some cases stretch back from historical times over millennia. One of the surprising consequences of our approach – and an indicator of the authenticity and reliability of the important genealogies we consider – is the chronological consistency of events in intersecting genealogies. Combining chronological information inherent in the genealogies that we study with independent astronomical and climatic evidence confirms the historical value and reliability of carefully preserved Maori and Polynesian traditions.

In Part III we demonstrate the extent to which the history of oceanic migration in the Pacific, in the first millennium AD and in the Medieval Climatic Optimum, was climate-modulated or climate-driven. We use El Niño low Nile flood proxy data, in combination with genealogical data, for example, to precisely date the first southern migrations to Hawaii to 1096, to date migrations within Eastern Polynesia led by Kahukura to 1230 and to date to 1200 the voyage of the Eastern Polynesian navigators, Hoaki and Taukata, which brought the kumara to New Zealand. All three events are linked to rare extreme El Niño events.

More remarkably, through study of two ancient genealogies preserved in the isolated Chatham Islands, we are able to propose a date for the first migration to New Zealand, a date that is supported by the power law analysis of Part II. This migration also is linked to a rare extreme El Niño event.

For events in the second half of the first millennium AD and in the Medieval Climatic Optimum (AD 1100–1400) we are able to achieve precise datings for major migrations using El Niño low Nile flood proxy data with an annual resolution. Dating these events precisely provides pillars for the chronology we sketch for climate-driven long-distance migrations in the southern Pacific triggered by El Niño-induced drought. Studying events for a period before data for low Nile floods was recorded, we rely on high-resolution climate proxy data from another source, a source that has proved equally effective for establishing a chronology for the climate-modulated history of the Lapita period and of the first millennium BC.

Analysis of titanium concentrations in sediments from Lake Huguang Maar in southeastern coastal China provides high-resolution dating for climate, volcanic and cometary events. Dating estimates from this source parallel and match those for events in the limited period covered by the El Niño low Nile flood proxy data. The chronological range of the Huguang Maar climate proxy, however, extends far beyond that of the low Nile flood data: it provides estimates for events over a span of 16,000 years.

A clear pattern emerges from our attempt to create a robust chronology through combining genealogical data with climate proxy data. This pattern reveals the extent to which the migration and voyaging history of the Pacific was climate-driven. For the period stretching from the first migration to New Zealand, which we establish in Chapter 20 to be close to 3,400 years ago, to the *Heke*, the last migration to New Zealand, which we date to AD 1403, most major migrations and significant voyaging activity in the Pacific (for which we can derive reliable estimates from carefully preserved genealogies) can be correlated with rare extreme climate events. As these climate events can be precisely dated, often to within a year, from climate proxy data, this opens new windows on the past. Sharp chronological estimates can be made for major events and the potential of carefully preserved genealogies as historical sources recognized.

In Part I, as the title of our book proclaims, study of oceanography and especially of the oceanographic history of the West Pacific Warm Pool, proves to be a key to the paths, sequence, timing and range of oceanic migration in two oceans. Parts II and III demonstrate a matching relevance for global climate history in its contribution to an understanding of long-distance migration and voyaging in the Pacific and Indian Oceans from the Lapita age (1600–1000 BC).

Oceanography and global climate history are, of course, closely related. ENSO events recorded in the low Nile flood proxy data that we call on in Part III can be thought of as oceanographic phenomena. The Kelvin and Rosby waves they generate travel the full width of the Pacific. In warm climate periods ENSO events can induce drought as severe as that of the 903 El Niño which toppled a dynasty in China and led to the demise of the Maya civilization of Mesoamerica. The El Niño drought and famine of 1096, which triggered simultaneous migrations to Hawaii from three different locations in tropical Polynesia, from Samoa, the Society Islands and the Marquesas, also led to the fall of the Zhou dynasty in China.

Climate events of Pacific-wide significance can be correlated with migrations and invasions in tropical Polynesia. Major volcanic eruptions strong enough to generate "nuclear winters" can induce global drought. The Huguang Maar Lake sediments carry evidence of such events, allowing us, for example, to date an early Taupo eruption to 1027 BC and to propose this as the cause of a near-extinction event in New Zealand recorded in Moriori tradition.

A surprising number of major events recorded in Polynesian history can be correlated with the most severe levels of ENSO events: events which are indicated both in the low Nile flood data and through titanium levels from the Huguang Maar Lake sediments. That El Niño events are recorded in the lake sediments is not surprising for the sediment data is correlated with the southerly movement of the intertropical convergence zone – a movement known to occur in El Niño years.

The consilience of dating estimates for major migrations and significant voyaging, based on genealogical estimates, with dating from climate proxy data with high resolution, demonstrates the extent to which Polynesian history is climate-driven. It also demonstrates the accuracy of traditional histories and of some of the rare, long, carefully preserved genealogies which underpin them.

1.6 Consilience

In successive chapters in Part I we present evidence in support of the central paradigm proposed in this book: that in the earliest phase of their exploration and colonization of the Pacific and in their establishment of the Cinnamon Route in the Indian Ocean, Spice Island mariners followed three of the four major fast warm currents flowing through and/or out of the West Pacific Warm Pool. We show that before 1000 BC and again when global warmth returned after 400 BC, at least three of these four currents were used by Spice Island explorers, traders and settlers as ocean highways. Flowing out of a volcanically heated West Pacific Warm Pool, these currents provided warm passage through colder oceans. Spice Island explorers using these highways were able to cover vast distances from the Spice Islands: to the north (through Micronesia to Japan), to the south (to New Zealand and just possibly along the coast of Western Australia), to the east (from Japan to Hawaii and America) and to the west (to Madagascar and the east coast of Africa). We show, moreover, how the sailing strategy of following fast warm currents out of the West Pacific Warm Pool could be used as an early exploration strategy that enabled Spice Islanders to discover and settle the largest uninhabited islands in two oceans (Madagascar and the North and South Islands of New Zealand) and to cross the full width of both oceans. We suggest that much of this exploration and settlement took place before 1000 BC when, as noted, an intense global cold period began which halted voyaging for at least 600 years.

Oceanic Migration makes the first attempt to comprehensively explore the maritime prehistory of the Spice Island ancestors of the Polynesian peoples. It highlights the factors needed to counter the risks of hypothermia and make their remarkable maritime achievements possible: warm global climate conditions, strong outflows not just of warm but of volcanically heated waters from the West Pacific Warm Pool providing anomalously high sea surface temperatures for its four major currents, creating warm highways across both oceans; high levels of genetic cold resistance and famine resistance in the Spice Island mariners; and the double usefulness of the sailing strategy of following fast warm currents as an exploration strategy capable of rapidly discovering and then later re-locating the largest uninhabited islands in two oceans. Our study of the Spice Islanders' maritime history reveals a wide-ranging, largely unexplored history of both early and late explorations and migrations in the Pacific and southern Indian Oceans.

In this brief Introduction we can offer only a crude outline of what we attempt in this book. Our chosen case studies in Parts II and III of the first and last prehistoric migrations to New Zealand, for example, are used to provide a focus for a new way of seeing the whole range of New Zealand prehistory and palaeodemography New Zealand palaeodemography, and to throw new light on the Pacific prehistory of which they are part. We draw on largely unexplored evidence bases. Mathematics is used in conjunction with areas of science such as genetics, demography and climatology. We study the diffusion and evolution of creation myths, study traditional oral histories and the genealogies that underpin them. The new understanding of New Zealand and Pacific history made possible through such an inclusive approach leads to what can only be described as a remarkable consilience of evidence.

It is perhaps useful to comment on the way we present our material in the book. First, where science meets prehistory we have deliberately avoided paraphrasing or simplifying the scientific sources on which our argument depends, preferring to quote researchers' words directly. When traditional Polynesian historical sources are important to our argument, as in Chapter 18, we quote them directly (albeit in translation) as primary texts. The Moriori genealogies and the main Rarotongan line that we discuss in Part III are supplied to the reader in an appendix. Visual representations of the patterns of ENSO events revealed in the low Nile flood proxy data are provided and the published graph of the Huguang Maar proxy data for the past 4,500 years provided with permission from the publisher. Presenting scientific, mathematical and primary historical sources directly, we feel, gives readers the opportunity to engage with the material involved and to weigh up for themselves the complex web of evidence on which we base the enlarged view of Pacific prehistory that we present.

The second point we need to make here is that the structure of our book is unusual in that each chapter explores part of a new context and each context provides a new window through which we invite the reader to view the past. We are seeking by this means to create a wider framework in which to understand the past. But we are also seeking cumulatively to achieve a synergistic effect through drawing together the insights from many different contexts, scientific disciplines and fields of evidence. In this sense we see science as a means, not an end. In using science to illuminate prehistory, what we are hoping to achieve is not scientific proof so much as a consilience of evidence that widens present understanding.

The implications of the word "consilience" deserve some comment. Our book is unusual in combining scientific evidence with evidence inherent in ancient tradition. Science can contribute to the art of history by certifying and establishing some of the facts around which history is woven. But history involves many elements more guessed than scientifically certifiable. For history is about people, their motivations, impulses and actions. It is about events whose causes are often multiple and sometimes hidden. Ancient history is even less knowable, less accessible than modern history. So much information has been lost that scenarios have to be constructed from fact-based surmise as well as from recovered artefacts.

Consilience has a role in underpinning surmise. It is a concept currently receiving new attention. The concept was advocated by E.O. Wilson [13], a modern scientist who, in the words of Iain McCalman [14], "strenuously advocated a return, Renaissance-style, to teaching the unity of knowledge". McCalman notes that Wilson draws inspiration from William Whewell [15], an early 19th century British philosopher who invented the term "scientist" and also advocated the less familiar idea of consilience. Wilson defines consilience as "a jumping together of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation".

We find Wilson's definition of consilience to be a good description not only of the concept itself but also of what we are attempting to do in this book. In the academic world specialization is the norm. The integration of knowledge tends to involve the combination of findings from a limited number of precisely delineated, currently popular, areas of specialized knowledge. Knowledge that does not belong to these areas tends to be forgotten or disregarded. We have gathered evidence from many areas and disciplines in this book. Perhaps the most original and interesting arguments in the book depend on the non-archaeological evidence we have drawn from areas that are rarely exploited as tools for prehistory. In calling on this new evidence and marrying it with the old and in combining traditional and scientific evidence, we have attempted to establish a consilience of evidence from the many areas and contexts, old and new, that we explore. We have tried, as Wilson puts it, "by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation".

The results are surprising. They have led us, for example, to argue that a "common groundwork of explanation" for the prehistory of the Spice Islanders can be found in elements defined by, or seen in terms of, many combining contexts. These combining contexts include the history, geography, economics, horticulture, oceanography, vulcanology, maritime technologies and the genetic and trading history of the Spice Islands. Viewing the prehistory of the Lapita and Polynesian peoples through all these frames gives shape and depth to the history we unfold.

To offer a second example, awareness of the maritime strategies of the Spice Islanders, especially in their early exploitation of fast warm currents and their avoidance of west–east sailing, led us to explore the possibility that the first settlement of New Zealand occurred as part of the Lapita expansion. Combining evidence from the study of Little Ice Age Maori hill-forts in the context of falling populations, evidence for large populations in New Zealand in the Medieval Climatic Optimum, with evidence from modern climate research, from mathematics and from a study of ancient genealogies, eventually enabled us to rethink the palaeodemography and chronology of Maori prehistory and to sketch a chronology for Moriori prehistory. We found that cumulatively the non-archaeological evidence we explored, together with demographic analysis based on skeletal studies and evidence from field archaeology, from ancient traditions, from the early observations of Europeans and from a power law analysis of the rank size distribution of New Zealand pa, provided striking support for a Lapita-age first settlement of New Zealand.

Overall, exploring new sources of evidence and studying new and known facts in new contexts has led to a consilience of evidence that we trust will persuade readers to look beyond limiting paradigms. We hope it will encourage them to explore new ways of looking at the remarkable oceanographic, climatic, cultural and genetic processes and events that led to the prehistoric peopling of the Pacific.

As a coda to this Introduction we might comment briefly on the special relevance of our study to a world facing significant climate change Global climate change. In this context the oceanic prehistory we unfold can be seen not as isolated and idiosyncratic but as part of climate-driven global history.

Our analysis of Maori demography after AD 1400, for example, offers a clear example of a climate-driven catastrophe from the past. Despite the size and relative resource capacity of New Zealand and the vigour, intelligence and resilience of Maori and their capacity for adaptation, we show large Maori populations struggling to avoid extinction in the Little Ice Age. In the 400 years before European contact, as climate extremes impacted on ecology, populations faced extinction in the poorer areas, and we estimate, even in the richest areas, faced starvation and a devastating population loss of the order of 93%. The fight for survival against European diseases and guns we present as a grim extension of that struggle.

We set our version of Maori prehistory during the Little Ice Age in the context of catastrophic population losses worldwide and, moreover, suggest that to be properly understood, the whole history of the settlement of the Pacific has to be read in the light of global climate history.

A report by the United Nations Intergovernmental Panel on Climate Change predicts that 100 million people are likely to be facing starvation by the end of this century as a warmer climate impacts on ecosystems, local climate systems, rainfall patterns and sea levels. It predicts massive associated migrations worldwide. Our study of the later migration history of the Pacific suggests something of the global nightmare we might face. Recurrently throughout history, resource-limited Pacific islands experienced climate-driven starvation as populations outstripped resources. Climate-induced famine, consequent conflict over land and resources and enforced migrations appear to have driven most migrations within the Pacific after about AD 900. Far earlier migrations can also be correlated with rare extreme climate events. The pattern of Pacific prehistory has demographic implications for a world in which resource ceilings have already been reached or breached in many countries so that their inhabitants are tragically vulnerable to global climate extremes. In microcosm our study of Pacific prehistory makes eminently clear how changing global climate patterns shape and have always shaped world history, migrations and demography.

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Chapter 2
The Genetic Context

Spice Trading, Cold Resistance and the Origin of the Lapita Peoples

Abstract The prehistory for the Polynesian peoples sketched in this chapter rests on mounting genetic evidence for a Lapita and Polynesian homeland in the Spice Islands. It rests too on recognition of the basic importance to the successful colonization of the Pacific of the genetic acquisition of cold resistance and famine resistance which conferred some protection against hypothermia. We argue that fundamental changes to the Spice Islanders' physiology and an evolution of maritime skills and technologies accompanied their progression from local to regional to international spice trading. That the ancestors of the Lapita and Polynesian peoples inhabited the Spice Islands suggests a coherent relationship in their prehistory between economics, geography, history and genetics. This relationship is explored in this chapter.

Keywords Genetics · Cold resistance · Famine resistance · Commensal animals · Halmahera

2.1 Introduction

The prehistory for the Lapita peoples that we present in this chapter has its evidence base in

(i) mounting genetic and other evidence for a Lapita and Polynesian homeland in the Spice Islands and specifically in Halmahera, the largest island in the archipelago;
(ii) recognition of the basic importance to the successful settlement of the Pacific of the Spice Islanders' genetic acquisition, over thousands of years of maritime trading, of cold adaptation and of the "thrifty gene" which conferred famine resistance, making it physiologically possible for them eventually to undertake transoceanic voyages in low-lying craft; and
(iii) recognition of the historical and practical implications of a Spice Island base for Pacific prehistory. We shall argue that the history and geography of the

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> Spice Islands made them a natural place for the evolution of maritime trading and associated skills and technologies. For in this ancient archipelago maritime trading, which had always been necessary for survival, expanded with a growing regional and international demand for spices that were unique to the Spice Islands. We suggest that an evolution in maritime skills and technologies marched with the evolution in maritime spice trading from a local to a regional to an international level. We argue that a very long history of maritime trading provided the selective pressures for the Spice Islanders' development of a cold-adapted, famine-resistant body type.

Central to our theory about the origins and prehistory of the Lapita peoples is evidence from Philip Houghton's studies of cold adaptation[1]. Houghton's research makes it clear that, without very high levels of genetic cold resistance and famine resistance, it would have been physiologically impossible for Spice Island mariners and their Polynesian descendants to have explored and settled every significant island in the Pacific Ocean or sailed across the width of the Indian Ocean to colonize Madagascar.

That the ancestors of the Lapita and Polynesian peoples inhabited the Spice Islands suggests a coherent relationship in their prehistory between economics, geography, history and genetics. It is this relationship that we propose to explore in this chapter.

2.2 Speculative Prehistories for the Lapita Peoples

First it seems appropriate to set the prehistory we propose for the Lapita peoples, as descendants of maritime Spice Islanders, in context with the prehistories that have gained most acceptance in the last 50 years.

Little more than 50 years have passed since the most exciting event in 20th century Polynesian archaeology took place. Though pottery had been found at Lapita in New Caledonia in 1917 [2], excavations in July 1952 yielded further ceramic pots. The subsequent discovery of "Lapita" pots in Fiji, Samoa, Tonga, in the Bismarcks and Solomons and numerous coastal settlements in Island Melanesia, an early dating for these pots of about 3,500–3,000 BP, and recognition of the significance of their distribution opened a new window on the colonization of the Pacific. Various versions of the first prehistory proposed for the Lapita peoples, as newly discovered ancestors for the Polynesians, have dominated Polynesian prehistory since.

This first prehistory, proposed by Diamond, Bellwood and Kirch [3], has been dubbed the "Out of Taiwan" model. The first variant, the "Express Train to Polynesia", using Green's terminology from a recent review of prehistories for the Lapita peoples [4], suggests a rapid migration from Taiwan to Polynesia, with little or no contact with indigenous populations in Island Southeast Asia. The second variant, the "Slow Boat to the Bismarcks" developed by Terell and Welsch [5], draws on Irwin's concept of a "voyaging corridor" [6] stretching from eastern Indonesia to the Bismarcks and Solomons, allowing for cultural interactions within this corridor, with associated cultural inputs from the Island Southeast Asian world into Near Oceania in the interval between 6,000 and 3,100 years ago. The third variant, the "Voyaging Corridor Triple I" [7], allows for the *intrusion* of new elements into the Lapita cultural complex during the migration process, with *integration* of materials and technologies from indigenous inhabitants in Near Oceania and *innovation*, the independent development of new technologies and components within the "voyaging corridor".

It is easy in retrospect to see the shifting of emphasis in these prehistories as corresponding to changing perceptions over time of the archaeological evidence. At first Lapita pots were seen as denoting a major cultural discontinuity, corresponding to the sudden arrival in Near Oceania of "pottery-using agriculturalists". Matthew Spriggs defines the change in cultural horizon for Near Oceania demarcated by the distinctive elements of the Lapita cultural complex. Spriggs lists the attributes of Lapita culture in contrast to earlier cultures in the region: the first convincing evidence of settled agriculture; the first appearance of the three Pacific domesticates, pig, dog and chicken, and thus the beginnings of Pacific animal husbandry; the distinctive decorative system of Lapita pottery, using dentate-stamping and incising; the building of stilt huts over lagoons; a distinctive Lapita stone adze kit; a distinctive range of shell ornaments; and a major extension in the trading range for New Britain and Manus obsidian from Sabah, in Borneo, in the west to Fiji in the east, a spread of 7,000 km [8].

Support for the theory of an Express Train from Taiwan to the Bismarcks was based on the strong early perception of cultural discontinuity. The arrival in Near Oceania of a more evolved culture from outside the region seemed an obvious explanation for such a discontinuity. A Taiwanese origin for the Lapita peoples, moreover, appeared to be supported by linguistic evidence . All three of the "Out of Taiwan" models – the Express Train to Polynesia, the Slow Boat to the Bismarcks and the Voyaging Corridor Triple I – rely on the fact that nine out of the ten Austronesian languages are spoken by the isolated indigenous tribes of Taiwan. Diversity is frequently considered a pointer to linguistic and genetic origins. But it is an incontrovertible fact that the tenth Austronesian language (to which all Polynesian languages and all other Austronesian languages outside Taiwan belong) is not spoken at all in Taiwan. The diversity of Austronesian languages in Taiwan, although the tenth language is not represented there, has driven speculative models for Lapita prehistory which claim a late Taiwanese origin for the Lapita peoples.

Pottery-making at the time that the Out of Taiwan theory was proposed was linked to the concept of a Neolithic revolution in which expanding farming populations replaced earlier hunter/gatherer populations. Pottery was associated with permanent settlement and with the storage of agricultural goods. The concept of a Neolithic expansion was tied to demographic evidence for a significant population increase following a change to settled agriculture. Thus the adoption of agriculture in the Fertile Crescent was seen as leading to population expansion with farmers moving inexorably across Europe 8,000 years ago, replacing earlier hunter/gatherer populations. Perhaps with this model in mind, Pacific prehistorians saw the Han

Chinese farmers who arrived in Taiwan about 7,000 years ago as likely ancestors for the pottery-making Lapita peoples. In line with the agricultural expansion in Europe, the Han Chinese migration was seen as a population expansion of Neolithic farmers, ultimately bringing agriculture and pottery-making to Near Oceania. Dates for pottery in Taiwan and the Philippines suggested these Lapita ancestors had arrived in the Philippines about 5,500 years ago, making their way to the Bismarck archipelago north of New Guinea about 3,600 years ago. The obvious flaw in this theory was the loss of their food staple, rice. The tree and root crops that the Lapita peoples carried into Near Oceanic and the Pacific were all domesticates from Island Southeast Asia.

This recognition fuelled the second "Out of Taiwan" variant, the Slow Boat to the Bismarcks, a theory designed to allow time for the Taiwanese rice farmers to acquire a completely new agricultural base in Island Southeast Asia. As precedents in Island Southeast Asia were found for some elements that at first were thought to be unique to the Lapita cultural complex, the Voyaging Corridor Triple I variant, in turn, was proposed. It allowed for a more comprehensive acquisition by the Taiwanese migrants of Island Southeast Asian technologies and for the possibility of their own developments of some of their acquisitions.

A second prehistory for the Lapita peoples, the "Bismarck Indigenous Inhabitants" model was proposed by White and Allen in 1980 and by Allen in 1984 [9]. It abandoned the "Out of Taiwan" model altogether, rejecting the need for migration into Near Oceania from elsewhere to explain the appearance of the Lapita cultural complex. This complex is seen instead as an indigenous development within Near Oceania. With the framing of this speculative prehistory, the range of possibilities for the Lapita peoples, from being seen as total outsiders to being seen as total insiders, was complete.

Though the concept of an agricultural expansion of Neolithic Chinese farmers to Near Oceania underlay the Out of Taiwan theory, the main support for their proposed migration was linguistic and genetic. However, a serious discontinuity for the theory of an agricultural expansion of Chinese farmers lay not only in the loss of their rice staple but also in the fact that it was the nine indigenous tribes of Taiwan, not Han Chinese farmers (supposedly the purveyors of agriculture and Neolithic technologies such as pottery-making), who are genetically and linguistically linked to modern Polynesians. The Han Chinese who invaded Taiwan about 7,000 years ago, in fact, drove these indigenous tribes into mountain refuges or on to the east coast where for the next 7,000 years they were effectively isolated not only from the Han Chinese but also largely from one another. The linguistic diversity, seen as proof that Taiwan was the homeland for the Austronesian languages, has lost its strength in the light of the more recent research of Friedlaender et al. Friedlaender et al. argue that both genetic and linguistic differentiation can be the hallmarks of isolation especially for inland tribes in large islands [10].

In Europe by 1995 the established idea of the Neolithic revolution, as an agricultural expansion which had led to the replacement of indigenous hunter/gatherers by Middle Eastern farmers, was being seriously challenged. Initially the genetic analysis led by Luca Cavalli-Sforza [11], which mapped the worldwide distribution of blood groups, had seemingly produced a water-tight case for the concept of a Neolithic agricultural expansion. As Martin Jones [12] explains, the first principal component in the principal components analysis of genetic variation adopted by Cavalli-Sforza and colleagues showed a series of bands running from southwest Asia to northwest Europe, supporting the idea of an expanding wave of farmers from the Fertile Crescent moving across Europe. Additionally,

> The second principal component highlighted a community on the fringes of this wave, and not actually part of it. The reindeer-herding Saami from northern Scandinavia (formerly known as Lapps) had followed a separate path from north-western Asia. The third principal component seemed to the authors to mirror another popular expansion, that of Maria Gimbutas' horse-riders of the steppes. Each principal component was elegantly pointing to a particular expansion, migration, or set of journeys (pp. 136–137).

But, Jones tells us, by 1995 Robert Sykes and his team in Oxford had realized that their own

> targeted analysis of one well-studied stretch of DNA was telling a quite different story from what had emerged from Cavalli-Sforza's masterly survey. They argued that, while a population spread of early farmers from south-west Asia had taken place, it only contributed a small fraction to the European gene pool. There was no wave of population advance sweeping across Europe, just a trickle. The sequence diversity had to be explained in terms of a more ancient population. Their hypothesis cut across the core journey within Cavalli-Sforza's grand synthesis. The principal ancestors of modern Europeans were the hunter-gatherers who were already there, thousands of years before the spread of farming. Agriculture travelled as an idea more than as a community, and the presumed population replacement had not taken place (p. 158).

Perhaps the "Slow Boat to the Bismarcks", proposed in 1997 by Terrell and Welsch, which allowed for cultural interactions of Taiwanese migrants with indigenous populations within Near Oceania, owed something to the radical challenge to Cavalli-Sforza's synthesis made by the Oxford geneticists. In contrast to the "Bismarck Indigenous Inhabitants" model of White and Allen, however, Terrell and Welsch's theory retained Taiwan as the ancestral homeland for the Lapita peoples and their Polynesian descendants.

Rejections of the concept of population replacement, implicit in the Out of Taiwan model, have appeared in the last few years [13]. Catherine Hill et al. [14], for example, challenge the claim that the modern inhabitants of Island Southeast Asia largely descended "from a second wave of dispersal, Proto-Austronesian-speaking agriculturalists who originated in China and spread to Taiwan 5,500 years ago" and from there "dispersed into ISEA 4,000 years ago, assimilating the indigenous populations". They see them, rather, as predominantly descended from the modern humans who colonized Island Southeast Asia 45,000–55,000 years ago. They address the poor quality of previous mtDNA data by sampling "almost 1000 individuals from locations throughout ISEA and by analysing the samples at a higher resolution than done previously by including coding-region as well as control-region variants gleaned from complete sequence data". The authors demonstrate that the majority of mitochondrial indigenous clades "appear to mark dispersals in the late-Pleistocene or early-Holocene epoch", long before the Out of Taiwan agricultural expansion is supposed to have occurred. This chronology enables them to link the earlier dispersals to the postglacial flooding that followed global climate change at the end of the last Ice Age. They conclude that “the strongest signals in our data appear to result from the movement and expansion of indigenous, rather than introgressive, mtDNA lineages, dating to between 15,000 and 5,000 years ago”. They note that only about 20% at most of modern mitochondrial DNA could be linked to an Out of Taiwan agricultural expansion in the mid-Holocene, suggesting that “if an agriculturalist migration did take place, it was demographically minor, at least with regard to the involvement of women”. Thus the authors reject the suggestion of a Neolithic expansion involving population replacement in favour of a more complex view of migrations in the region involving large-scale postglacial dispersals over possibly a 10,000-year period triggered by global climate change.

This interpretation is reinforced in a paper by Pedro Soares et al., published in 2008 [15], using “the sequence variation in complete mtDNA genomes to investigate the possibility that a signal of late glacial and postglacial dispersals exists in ISEA” (p. 1209). This paper concludes that “global warming and sea-level rises at the end of the Ice Age, 15,000–7000 years ago, were the main forces shaping modern human diversity in the region”. The authors, moreover, argue that

> archaeological evidence provides independent support for a large-scale dispersal across ISEA (or central/eastern Sundaland and Wallacea, as the region then was) during the 15,000 years after the LGM [Last Glacial Maximum]. . . The signature of dispersals from this region at the end of the Ice Age is evident both in the distribution of mtDNA haplogroup E lineages and the expansion of the flake-blade technocomplex (p. 1216).

In his classic work *Eden in the East, The Drowned Continent of Southeast Asia* [16], Oppenheimer not only presents genetic evidence in favour of an ancient Polynesian homeland in Wallacea for the Polynesian peoples but also draws on evidence from many sources to support his thesis that the Moluccas, the Spice Islands, possessed a very ancient culture and were a major centre for the diffusion of culture. He provides evidence, for example, for the diffusion of myths from the Spice Islands to Mesopotamia, the Middle East, Europe, Asia and the Pacific:

> In our discussion of the ‘Garden of Eden’. . .the tiny islands of Maluku were the epicentre of the immortality myths, the creative tree and its main descendant – the dying and rising god. The added motif that gave the ‘dying and rising god’ story its tragic flavour was the myth of the two brothers. The genetic and linguistic mix in Maluku gives a much older glimpse of the transition between Asia and Melanesia than the conventional dating of the Austronesian dispersal allows [17].

Traders have always had a major role in the dispersal of myths and cultural practices. Oppenheimer’s evidence for the diffusion of culture from the Spice Islands fits well with the role we propose for the Spice Islanders as the earliest international maritime traders. The antiquity of Moluccan (Spice Island) myths and the range of their maritime dispersal support the antiquity of Spice Island indigenous culture and emphasize the strength and range of Spice Island cultural influence, both through maritime trade contact over millennia and through pre-flood land migrations via Sundaland to the Middle East and Europe. The strong cultural link of the

Lapita colonists to their Moluccan homeland can be seen in the tree worship practised in every Lapita colony. Sacred fig trees with aerial roots (a symbol of contact between heaven and earth) were transplanted to each colony and worshipped as living embodiments of the Cosmogonic Tree. Lapita tree worship and the survival in New Zealand and the Chatham Islands of ancient, probably Lapita age, associated rituals are studied in depth in Chapter 17.

2.3 Genetic Evidence for a Lapita Homeland in Wallacea

Oppenheimer [18] cogently summarizes the human genetic evidence for a Wallacean indigenous ancestry for the Polynesians. We quote his summary in full because the prehistory that we propose for the Lapita peoples and for other groups of Spice Island descent partly depends on this evidence. Oppenheimer explains that

> Several genetic marker systems point to a primarily island Southeast Asian ancestry for Polynesians. The 'Polynesian motif,' a unique suite of four single nucleotide polymorphisms in mtDNA, identifies an Oceanic subgroup within a widespread West Asian mtDNA cluster, known as haplogroup B, and characterized by an intergenic 9-base pair deletion. This Oceanic subgroup is also the main variant throughout the lowland populations of coastal Melanesia, and the bio-geographic zone of Wallacea. Most importantly, it is almost absent to the west of Wallace's Line. It is not found in the Philippines, Taiwan or China – all key stations along the Express Train route. Instead, in these regions we find its immediate ancestor with only three of the four polymorphisms.
>
> The possibility that the final mutation nucleotide 16 247 occurred 'en route in the Express Train' is rendered less likely by a study of the diversity accumulated by the Polynesian motif in Wallacea and Melanesia to estimate its age using the Molecular clock. In other words, the motif originated before an express train carrying Taiwanese farmers could have arrived in Wallacea. This seems to break the train ride somewhere around Wallacea... This finding suggests that Wallacea, a buffer zone between Island Southeast Asia and Melanesia, might have harbored an ancient, indigenous population (of ultimately Asian origin) from which the Polynesian colonists emerged. Study of Y-chromosome variation in the region supports a similar conclusion, and indeed earlier autosomal studies and physical anthropology also suggests ancient differentiation between mainland Asia, Taiwan, Island Southeast Asia, and Melanesia. It is difficult to reconcile this evidence with the Express Train-out-of-Taiwan; it seems more consistent with very ancient Austronesian origins within tropical Island Southeast Asia.

Performing the necessary mathematical calculations for the genetic timing of the fourth polymorphism of the 'Polynesian motif', Richards, Oppenheimer and Sykes suggest that the mutation occurred, not in Taiwan but in Wallacea and that the mutation occurred about 17,000 years ago [19]. (Oppenheimer, however, notes in a later paper that "Wallacea has the oldest estimate for the Polynesian motif at 17,000 years, but this figure has a high standard error. Two independent estimates based on much larger data sets from New Guinea produce >10,000 years" [20].) Oppenheimer argues that "The distribution of the final PM genetic innovation places Wallacea as the likely source of the commonest maternal genotype in lowland Oceania" (p. 597).

In 2004 Oppenheimer proposed a Y chromosome equivalent of the mitochondrial Polynesian motif [20]:

> The dominant Polynesian Y haplotype (50–80 percent) belongs to a widespread ancient Asian 'haplogroup 10' (Hg10) defined by an RPS4y marker. An early introduction to Asia and Australia in the Late Pleistocene (Oppenheimer 2003: 184–193), Hg10 is mainly found in those regions as locally mutated derivatives, although it is notably absent from Taiwan and the Philippines. The root ancestral form has been found only in India, Borneo and Wallacea – the latter a region where Hg 10 has acquired a new Oceanic mutation M38. M38 is the only Hg10 type found in the rest of the Pacific. This could be the male analogue of the Polynesian Motif: it is ultimately Asian, may originate in early Holocene Wallacea or north coastal New Guinea, is absent from the New Guinea highlands, and is common in Polynesia. Age estimates are c. 11,500 years for the western Pacific, with a later expansion signal dated c. 5000 BP. In Polynesian groups a strong expansion signal appears dated to c. 2,200 BP, indicating multiple pulsed expansions at different times (Kayser et al. 2000).

(We note that the expansion signal dated to 2,200 BP coincides with what we term "second-wave" Spice Island migrations, which followed a 600-year hiatus in long-distance voyaging caused by a severe cold period between 1000 BC and 400 BC.)

Recent genetic evidence – most notably the mitochondrial studies of Trejaut et al. [21] and of Friedlaender et al. [10] – have affirmed significant mitochondrial links between the nine indigenous Austronesian-speaking tribes of Taiwan and populations in Luzon, the Philippines and the Moluccas or Spice Islands. However, far from supporting the Out of Taiwan hypothesis, the new evidence raises questions about the timing of gene flow between Taiwan and the Spice Island region. Estimates for coalescence times for the new haplogroups (B4a1a and B4a1a1) studied by Trejaut et al. and Friedlaender et al. establish genetic links, possibly dating back to the late Pleistocene or early Holocene. The timing for the evolution of the mitochondrial mutation np 14022 in the Moluccas that defines the later haplogroup B4a1a1 is dated between 11,500 and 6,800 years ago. This mutation separates Spice Islanders, coastal Papuans and Polynesians from populations in Taiwan, Luzon and the Philippines, implying that there is no modern evidence for significant genetic interactions affecting mitochondrial DNA taking place between these two groups of populations after this time. It thus fails to support the hypothesis of a slow Taiwanese migration via the Philippines (c. 5,500 BP) to Near Oceania (c. 3,600 BP).

The Express Train to Polynesia implies both that the Han Chinese invasion of Taiwan is to be read as a Neolithic expansion of agriculturalists and that the Lapita migration was part of that expansion. But, as we have noted, it is not the Han Chinese (who today form 98.5% of Taiwan's population) who are linked through their mitochondrial genes with populations in Wallacea. It is the nine indigenous Austronesian-speaking Taiwanese tribes that possess this link and their history for the past 7,000 years, far from being one of expansion, has been one of genetic and linguistic isolation. As evidence of this persisting isolation, one tribe, the Bunum, practised head-hunting until the early 20th century [22]. The long isolation of the indigenous Austronesian-speaking tribes in Taiwan appears to have led to the kind of genetic and linguistic differentiation that Friedlaender et al. see as typical of isolated inland tribes in larger islands [23]. Isolation can account both for the evolution of nine separate Austronesian languages, one per tribe, and for the preservation in Taiwan of ancient maternal lines whose coalescence times suggest they stretch back to the late Pleistocene. These maternal lines do not possess the later mutations which occurred in Wallacea and which genetically separate populations in the Spice Islands, coastal Papuans and Polynesians from indigenous Taiwanese and populations in Luzon and the Philippines.

Linguistic diversity can be a pointer to linguistic origins, and claimants of the Out of Taiwan theory have claimed an origin for the Austronesian languages in Taiwan. But isolation can lead to both linguistic and genetic differentiations and in Taiwan we have circumstances explaining both. Genetic differentiation through isolation explains why the nine indigenous Taiwanese tribes are closer through their founding haplogroup B4a1a to populations in Luzon, the Philippines, the Spice Islands and Indonesia than they are to one another. Linguistic isolation accounts for the fact that not only are their nine languages distinct from one another but they are also distinct from the tenth Austronesian language spoken by all other Austronesian speakers.

Three defining mutations carried by Spice Islanders, coastal Papuans and Polynesians but not by indigenous Taiwanese and populations in Luzon and the Philippines, then, appear to have occurred in Wallacea in the late Pleistocene or early Holocene. The fourth polymorphism that defines the Polynesian motif dated variously between 10,000 and 17,000 years ago, a second mitochondrial mutation np 14022 which Trejaut et al. show differentiates the B4a1a1 haplogroup from the earlier B4a1a haplogroup, with a coalescence estimate from 6,800 to 11,500 years, and the Y chromosome mutation M38 dated to about 11,500 years ago. Genetic interactions between male traders and women from other populations would not have affected the mtDNA of those populations but would leave a record in the Y chromosome genes of those populations. That M38 has left no mark on populations in Luzon, the Philippines and Taiwan means that, based on the genetic data for all three mutations, possibly the estimate of 11,500 years for M38 might be a reasonable estimate for the last genetic interchange of these populations with Wallacea. The estimate for M38 also fits with the chronological bounds for the mitochondrial mutations. That is to say, it might be a reasonable estimate for the last genetic interchange which can be recognized from all-male and all-female lines in current populations in these areas. Stretching back to the late Pleistocene or early Holocene, these combined estimates predate by 8,000 years the estimated dates for the Express Train to Polynesia and probably also predate those for the Slow Boat to Polynesia. But they support the case for an ancient indigenous Lapita and Polynesian homeland in Wallacea.

We suggest that ancient migrations need to be viewed in light of the oceanographic history of the West Pacific Warm Pool and its role in shaping Spice Island trade and migration paths. They also need to be viewed in the context of the cataclysmic reshaping of lands bordering the West Pacific Warm Pool by rising sea levels between 13,500 and 7,500 years ago. The drowning of vast stretches of former continental shelf along the coast of mainland China and the drowning of the ancient continent of Sundaland provide a vital background for understanding the genetic and trading history of Island Southeast Asia and the record of ancient migrations implicit in the genes of modern populations in the region.

2.4 Evidence for a Spice Island Homeland from the Study of Commensal Animals

As noted in the Introduction, in addition to direct genetic evidence for a primarily Wallacean ancestry for Polynesians, the work of the archaeobiologists Elizabeth Matisoo-Smith and J.H. Robins powerfully and specifically supports the idea of a Spice Island homeland for the Lapita and Polynesian peoples, centred in Halmahera [24]. The Pacific rat, *Rattus exulans*, which was carried into the Pacific as a food animal by the Lapita peoples and their descendants, the Polynesians, is found in all Lapita archaeological sites. But it was absent in Taiwan until very recently. It is found with greatest haplogroup diversity in the Spice Islands. Matisoo-Smith and Robins trace the two haplogroups of *Rattus exulans* which are found in the Pacific to Halmahera, establishing this island as the homeland for the Pacific rat and, by implication, for the people who carried it into the Pacific.

In 2005 the 13 authors of a major worldwide study of centres of pig domestication [25] showed that the pig carried into the Pacific by the Lapita peoples was unrelated to the Taiwanese wild pig:

> Our data also have implications for conflicting hypotheses regarding Pacific prehistory... The New Guinea pig haplotypes in this study cluster with pigs from Hawaii, Vanuatu, and Halmahera in a monophyletic group (here termed the 'Pacific clade') within the large Eastern Eurasian cluster and are well separated from any other individuals, domestic or wild... This evidence is consistent with a Lapita dispersal from Near to Remote Oceania, but the lack of any genetic affinity between this group and Taiwanese wild boar...offers no support for the 'Out-of-Taiwan' model of human and pig dispersal into Near Oceania. This evidence also supports the importance of Halmahera, which has been shown to be the origin of Remote Oceanic populations of the Pacific rat (*Rattus exulans*) transported by the Lapita peoples and the origin of the human mitochondrial marker known as the 'Polynesian motif' (pp. 1620–1621).

In 2007 in an article involving 32 researchers, Larson et al. [26] argued that

> Pigs representing the Pacific Clade originated in East Asia, potentially in peninsula Southeast Asia, where we suggest they were initially domesticated. They were subsequently introduced to the Sunda Islands, the Moluccas, and the New Guinea region. In addition, the Lapita and later Polynesian dispersals into Oceania appear to be exclusively associated with Pacific Clade pigs (p. 4838).

They note not only that the Taiwanese pig is unrelated to the Pacific clade but that pigs in the Philippines, supposedly on the migration route to Near Oceania from Taiwan, are also unrelated to the Pacific clade:

> the Pacific signature was absent from samples from Taiwan (which included native wild and domestic modern pigs and an ancient domestic sample), and none of the 40 wild samples from the Philippines (identified as endemic *S. Philippensis*) or the 17 introduced domestic samples from two central Philippine islands, Panay and Cebu. Instead, wild boar from the Philippines form a distinct clade within the basal portion of the tree (p. 4836).

Genetic evidence from a study of the dispersal of pigs into the Pacific thus fails to support the purported late route of the Lapita peoples from Taiwan via the Philippines to Near Oceania. The introduction of *Sus scrofa* into the Sunda Islands, the Moluccas and New Guinea region establishes instead a base in Wallacea or Near Oceania for their introduction into the Pacific.

The recent genetic research focussed on Polynesian commensal animals has highlighted the role of Wallacea generally and the Spice Islands in particular as a major centre for plant and animal domestication. The Spice Islands might almost be thought of as an Island Southeast Asian "Fertile Crescent". Not all the animals that formed the basis of the agriculture they practised were indigenous to the Spice Islands. The pig came from peninsula Southeast Asia, the Polynesian chicken has at least two separate sources in mainland Asia and, like the pig, was presumably brought to the Spice Island region by Spice Island traders. The Spice Island mariners who first carried their plant and animal domesticates into the Pacific brought them to uninhabited islands. There, as we shall see in Chapter 7, the process of domestication continued. Similarly, the hybridizing skills of the Spice Islanders' descendants were used to genetically modify plants to meet the new climates and soil conditions they encountered or to serve evolving cultural practices. These skills, as we noted in the Introduction, enabled Spice Island colonists to turn depauperate Pacific islands into lands capable of supporting significant populations.

The possibility that the Spice Islands were a diffusion base for the spread of Asiatic chickens to America is considered in detail in Chapter 6. The recent genetic evidence of Storey et al. for the pre-Columbian introduction of the Polynesian chicken to America [27] is discussed together with both linguistic and cultural evidence for the diffusion of the chicken within America from a base in northern Mexico (close to the southern coast of California, the landfall to which the Kuro Shio Current would have drawn the canoes of Spice Island explorers and traders).

2.5 Polynesian Cold Resistance and Famine Resistance: Houghton's Evidence

Understanding Houghton's research and its implications is vital to any debate about Polynesian origins. Houghton demonstrates that without the selective advantage of genetic cold resistance and famine resistance, Spice Island mariners and their Polynesian descendants would have been physiologically incapable of exploring and settling islands scattered across a quarter of the globe. We attempt in the following pages to summarize his research as a vital evidence base for the prehistory we propose for the Spice Island ancestors of the Polynesian peoples as early maritime explorers and spice traders.

The Polynesian cold-adapted body type is characterized by a tall body, a round head, a long thick trunk and short thick arms and legs and a large muscle-mass. Anatomists are said to be able to recognize a Polynesian skeleton from uniquely large muscle attachments visible on the bones. The selection principles involved are, of course, a limiting of the body's surface in relation to body mass to reduce loss of body heat and a maximizing of muscle mass to enable maximal capacity for exercise and for shivering, both of which generate body heat and are major protections against hypothermia. Houghton [1] supports Damon's conclusion that "Climate. . .does indeed seem to be the major regulatory factor for human body size and proportion" and he notes that this statement subsumes the classical biological rules of Bergmann (1848) and Allen (1877):

> Bergmann's rule says that, for closely related mammals or birds, those living in cold regions tend to have greater body mass than those living in warm regions. Allen's rule says that animals living in cold climates tend to have shorter extremities than those living in hot climates. . . In human terms, larger and more muscular people should be found in cold climates, where large muscle mass can produce more body heat, and the relatively smaller surface area of a larger body lessens heat loss. Smaller-bodied, or at least more linear, people should be found in hotter climates, where endogenous heat production is less necessary, and a relatively larger surface area allows for more efficient cooling. The geometric basis is that the volume and mass increase as the cube of the linear dimensions, whereas surface area only increases as the square of the linear dimensions (p. 167).

Statistics based on factors such as stature/weight index and sitting to standing height index (ratio $\times$ 100), which are measures of a cold-adapted body type, suggest that New Zealand Maori are more cold-adapted than any other recorded cold climate group. Eskimos and Lapps have sitting to standing height indices of about 52.5, Maori has one of 53.8 [28]. The stature/weight index "ranges from under 2.6 for males from cold climate regions such as Finland, Iceland and England, through to values above 3.2 for Vietnam, Burma and India (Molnar, 1983). The Polynesian male values of between 2.22 and 2.39. . .are lower than that recorded from any cold-climate group" [29].

Houghton concludes that the extreme cold adaptation of the Polynesian body type relates to an oceanic environment that poses very significant risks of hypothermia: "The oceanic environment is potentially and very frequently very cold, whether for voyaging, for the more mundane but routine activities of reef and coastal fishing in a small-island existence, or at times even for life ashore" [30]. With respect to canoe voyaging, Houghton quotes heat loss and heat gain figures which illustrate the advantage of muscle mass in cold responses and demonstrates the advantage of the Polynesian phenotype over that of a non-cold-adapted individual in wet/cold oceanic conditions conducive to hypothermia:

> These heat loss and heat gain figures show that in wet/cold conditions at sea – relatively inactive, shivering and exposed – the smaller body is able to produce only 42–43% of body heat lost, with an hourly deficit of 1800–1950 kJ. The larger body is better off but, for any individual, such exposure is unsustainable for more than an hour or so. For example, Pugh (1967) noted a drop of core temperature from 39.5°C to 36.4°C in 25 minutes in an inactive subject in wet-cold conditions of 5°C and 14 kph wind.
>
> If shelter is largely obtained from the wind – say to about 4 kph – the heat loss is reduced to about half the exposed loss (Pugh 1966, Clark and Edholm 1985). Thus, with a heat production of about 1750 kJ/hour, the large body can just maintain heat balance. The small body remains in deficit of about 300 kJ/hour. . .With such a deficit a core temperature of about 32°C, a condition of moderate hypothermia, is reached within eight hours. . .If the maximum heat output from shivering has already been reached, such increase would have to arise from deliberate muscular activity (p. 174).

Houghton speaks of the value of exercise such as paddling a canoe in sustaining heat levels:

> During such moderate exercise both phenotypes [cold-adapted and non cold-adapted] would be still in considerable heat imbalance under the conditions defined above of temperature 14.5°C, 91% humidity and 16 kph wind. The larger body is producing about 62% of the heat being lost, the smaller body about 53%. However, these conditions can be related to the realities of canoe existence. During severe wet-cold exposure conditions, progress under sail would be possible and physical activity for most of the crew restricted; they would be huddled down out of the wind and protected by whatever (damp) coverings were available. Heat balance of the large muscular body could be maintained for long periods by shivering. Smaller individuals would range in condition from chilled to hypothermic or worse, depending on body size and the time the severe wet wind-chill conditions persisted (p. 175).

Houghton concludes:

> I suggest that, whatever the mean air and water temperature, the environment of Remote Oceania is effectively the coldest to which *Homo sapiens* has adapted and, at the time of Western contact, the people of the region displayed the supreme cold-climate body form. This influence of environment is pervasive, going beyond simple consideration of infracranial proportions and muscularity to shape the distinctive Polynesian head and dentition (Houghton and Kean 1987) (p. 174).

Houghton's study of the evolution of the distinctive form of the Polynesian head [31] illustrates how complex and extensive the morphological changes consequent on the evolution of the Polynesian cold-adapted body form were. The need for a larger airway, needed to supply oxygen to the larger Polynesian muscles, for example, required a greater vertical development of the face. Houghton argues that airway size

> is appropriate to oxygen demand and it follows that the extent to which oxygen demand varies between individuals at maturity determines the extent to which the face develops vertically. Amongst adults, differences in anterior nasal height as a simple indicator of airway size are a rough reflection of differing body size, and particularly of differences in muscle mass, for from this tissue comes the great oxygen demand during activity. . .On the basis of the preceding discussion, nasal height in large muscular Polynesians ought to be in the upper range for *Homo sapiens*, and this proves to be so. For a large global series Howells (1989) gives a range from 42.76 to 56.91 mm for males and 42.86 to 53.33 mm for females. Top of the range for each sex are the Siberian Buriats (a most distinctive, inland, continental, cold-climate people). Chatham Island Moriori are next with values of 55.95 and 52.61. People of Remote Oceania (Hawaii, Guam and Easter Island) take up three of the next five places in the range, along with the Arikara and the Inuit. For the New Zealand Maori, Wagner (1937) gives values of 54.3 for male and 51.4 for female, and for Marquesas, 57.4 for males – surpassing the Buriats – and 52.7 for females (p. 108).

Houghton explains that provision for a larger airway required the flattening of the cranial base:

> The cranial base is an interface between two functional regions, for as well as supporting the brain it also forms the roof of the airway. Berglund (1963) establishes that flattening the cranial base led to an increase in volume of the nasopharynx and derived a formula for its calculation:

$$\text{Capacity of bony nasopharynx} = (\text{posterior nasal spine to basion distance}) \times \text{chonal width} \times (\text{perpendicular from hormion to basion-posterior nasal spine line})/0.5$$

Using this formula we established a mean volume of 13.0 ml for the male Polynesian nasopharynx, compared with 10.1 ml for Norwegians and 0.5 ml for Australian Aborigines. That is, the Polynesian nasopharynx is on average about 30% larger than that of northern European, and 35% larger than that of the Australian Aborigine (Kean and Houghton, 1972). This is a substantial difference, and the influence on the voice of such a great resonating chamber above the vocal cords (Sundaberg 1977; Proctor 1980) may contribute to the well-attested Polynesian singing abilities (pp. 108–109).

The extent and complexity of these changes are remarkable: the evolution of the greater lung capacity and larger airway needed to supply oxygen to fuel larger muscles led to a complex reshaping of the head, involving the development of a larger cranial vault and large cranial capacity and so the evolution of the recognized pentagonal shape of the Polynesian skull, while changes to the mandible led to the evolution of the rocker jaw. With respect to the latter, Houghton comments that

The mature mandible represents the most extreme adaptation of the bone found amongst *Homo sapiens*, and within Polynesia the Moriori with their exceptionally flat cranial bases show the most extreme form of rocker jaw (p. 111).

Summarizing the results of his metabolic analysis, Houghton concludes [32]:

These figures for heat production and heat loss show that, in the oceanic environment with only neolithic technology, a larger-bodied individual is at a quantifiable and crucial advantage in maintaining body temperature. In addition, a thick muscular limb maintains its warmth and function better. In these wet-cold oceanic conditions only an individual approaching Polynesian proportions and muscularity could generally sustain body heat and limb function. For individuals of lesser build the consequences would range from extreme discomfort to hypothermia and death, depending on the persistence of the windy, wet-cold conditions (p. 174).

We have quoted from Houghton's analysis in detail because its implications for the prehistory of the ancestors of the Lapita and Polynesian peoples are so striking. Houghton notes that the evolution of a cold-adapted phenotype may have its roots in a distant past: "The time that the selection for large body size took is uncertain, but there is a big gap between the earliest date for human occupation of New Ireland, 33,000 BP (Allen et al. 1988) and the appearance of Lapita ware with its voyaging associations about 3600 BP (Green 1982)" (p. 180).

Jim Bindon [33] has argued that recent research into thrifty genes has provided some clues that the cold- and work-adapted body build and the metabolic shift to accommodate dietary stress may be related:

These adaptations may be the result of mutations in the region of the insulin gene (INS), like the variable number tandem repeat (VNTR) polymorphism near INS that modulates transcription of both the INS gene and the nearby Insulin-like Growth Factor 2 (GF2) gene. Increasing transcription of INS could generate high blood insulin levels (hyperinsulinemia) and decrease sensitivity to insulin binding in peripheral cells (insulin resistance). Meanwhile, high levels of IGF2 stimulate muscular and skeletal growth predisposing to a large, robust body.

He adds carefully,

> I do not mean to imply that this particular VNTR polymorphism represents the thrifty gene, but it points to a possible area for exploration and integrates the biological adaptations found in modern-day Polynesians that appear to result from their voyaging history.

Joanna Poulton [34] suggests that the first (oldest) polymorphism (at 16189) of the four polymorphisms that define the Polynesian motif may be linked to famine resistance, which, as we have seen, is a physiological concomitant to cold resistance, sustaining shivering and muscular exertion which are the best physiological means for actively fighting hypothermia. The antiquity of this Ice Age polymorphism and the survival advantage it offers in times of famine may be reflected in its wide distribution in east Asia, Mongolia and North and South America. The statistical correlation that Poulton demonstrates between the first substitution (16189) of the Polynesian motif and diabetes mellitus, and so possibly with genetic thrift or famine resistance, suggests that mitochondrial genes may have been at least partially involved in the evolution of Polynesian famine resistance. But it is unlikely, given the complex morphological changes involved in the genetic selection for cold resistance, that the genes governing cold adaptation simply belong to the faster-evolving mtDNA and Y-chromosome parts of the genome. The first mitochondrial polymorphism that Poulton quotes as possibly being associated with famine resistance is estimated to be 60,000 years old [35]. As the full evolution of high levels of cold resistance in Polynesians may have involved a raft of slowly evolving genes, it is hard to imagine the time scale for such evolution requiring anything less than tens of thousands of years.

Along with their cold-resistant phenotype, the "thrifty gene", coding for hyperinsulinemia, enabled the Polynesians to survive not only the famines that occurred in the tropical Polynesian islands and are recorded from AD 900 onwards in traditional histories (see Chapter 19), but also the extreme exertion needed to fight hypothermia in a canoe on the ocean. We believe these genetic and physiological facts, which underpin our prehistory for the ancestors of the Lapita and Polynesian peoples, support our claim that it was highly likely that Spice Islanders had been regional maritime traders for probably tens of thousands of years before they colonized Micronesia, Island Melanesia and Western Polynesia. Their cold resistance and famine resistance were vital to their role as maritime traders and were arguably a long-term consequence of this role. They were equally vital to their eventual role as long-distance maritime colonists and, much later, as we shall see in Part II, to their survival of cold and starvation in New Zealand in the Little Ice Age.

Whether or not the evolution of the Polynesian body form took 30,000 years, Houghton's research establishes that it must have developed in response to many millennia of exposure to life in an oceanic environment. His research explains the selective advantages that cold resistance and famine resistance would have given Spice Islanders and their Polynesian descendants in exploring and colonizing the Pacific. It explains why they proved to be the only people to colonize the Pacific and how they were able to sail the Cinnamon Route from the Spice Islands to the east coast of Africa, with a probable stretch of 4,000 km without landfall to reach Madagascar.

It is a remarkable fact that these selective adaptations occurred in a people living not in the Arctic or in a high latitude but in Spice Islanders living on the equator. Biological evolution in the region is tied to the Ice Age and post-glacial history of Sundaland and Wallacea. Sundaland and Sahul were Ice Age refuges for people coming from as far away as Africa and as long ago as 85,000 years. They were Ice Age refuges too for countless species of plants and birds and animals, including miniature elephants and numerous species of apes. They made possible the evolution of the amazingly colourful birds and butterflies and insects collected by the naturalist Alfred Russel Wallace from 1854 to 1862. His observations in the Malay archipelago of laws of natural biological evolution led to his perception of the principles governing evolution and so to his formulation of a theory of natural selection. Hominid species dating back over half a million years and the newly discovered but currently controversial Flores "hobbits" suggest too that Sundaland, and especially Wallacea, may have been an Ice Age refuge in earlier Ice Ages. The pressures for selective adaptation can be seen in many of the Ice Age refugees. Both miniature elephants and even possibly miniature people (the "hobbits") were adapting through size reduction to survive on depauperate islands. Andamese women adapted to limited food availability through developing the condition known as steatopygy which enabled them to store remarkable quantities of fat in their buttocks as a food supply against famine and as a food supplement during pregnancy and lactation. Survival drives such adaptations. In the case of Spice Island mariners, ancestors of the Polynesians, as for the cold-adapted Neanderthals in Europe, we suggest that Nature took exposure to a long-standing continuous risk of hypothermia seriously.

With the Out of Taiwan hypothesis the supposed later Taiwanese ancestors of the Lapita and Polynesian peoples could conceivably have "picked up" maritime skills and technologies en route to the Bismarcks, on either an Express Train or a Slow Train from Taiwan, but the evolution of a cold-adapted phenotype involves genetic evolution through natural selection rather than cultural adaptation. Unless the Lapita peoples were on an Express Train from the Arctic, the development in people living on the equator of cold resistance greater than that of Inuit and Lapps suggests a very long maritime history. A considerable time was needed for the requisite genetic mutations and for the coalescence of these mutations, so that they were present in a significant proportion of Spice Islanders before they set out to settle the Pacific.

2.6 Houghton's Prehistory for the Proto-Polynesians

What selective pressures resulted in such an extreme measure of cold adaptation for the ancestors of the Polynesians? Houghton's answer was that these pressures were geographical and occupational. He speaks of the selective pressures of particular environments and argues that "the selective model predicts that genetic relationships will follow geographic and local lines" [36].

Houghton argues that the ancestors of the Polynesian peoples evolved from Melanesian maritime peoples in Island Melanesia:

> In the archaeological record of Island Melanesia the Lapita culture, with its evidence of extensive voyaging, is considered to relate to the emergence of pre-Polynesians (Green, 1982). Human skeletal material from secure Lapita contexts is still sparse, but all materials so far examined is from tall and robust people (Houghton, 1989), supporting the idea of the evolution within Island Melanesia of a large-bodied people adapting to the maritime environment. Such a large-bodied form is inappropriate to the tropical environment further west, and has not been recorded there. . .Initial settlement of Polynesia and Micronesia must have been by Melanesian people already adapted, physically and technologically, to the oceanic environment, and the genetic data suggest that the original settlers of these two regions were quite closely related (pp. 57–58).

Houghton comments that there are large maritime people who live on small islands in Island Melanesia and small non-maritime bush people who also live on small islands in Island Melanesia. He correlates the non-cold-adapted Melanesian peoples with non-maritime ways of life. He points out that in conditions "verging on severe hypothermia. . .the Melanesian bush people would simply not survive" (p. 54). Houghton sees the job descriptions of these large maritime and small bush people as determining genetic outcomes. But the argument can be set the other way around. If people are not cold-adapted, they will not take up a maritime way of life if they can avoid it, because it is too unpleasant and risky.

Houghton saw Island Melanesia as representing the geographical and historical transition between Near Oceania and the Pacific. His argument for selective adaptation, therefore, focuses on Island Melanesia as the logical place for the robust cold-adapted body form of the Polynesians to have evolved. The distribution and dating of Lapita pottery, however, imposes what we see as an impossibly tight time frame on such evolution.

Developments in genetics since Houghton published his research give us two advantages in interpreting the genetic history of the Lapita peoples and of their Polynesian descendants. First, we have a geographical advantage in knowing that the Lapita homeland was in Wallacea and more specifically in Halmahera. As a counter to Houghton's claim that there are no cold-adapted people to the west of Island Melanesia, we can quote the description of the people of Halmahera (Gilolo) by Alfred Russel Wallace in *The Malay Archipelago* (1869) [37]:

> In the evening we stayed at a settlement of Galela men. These are natives of a district in the extreme north of Gilolo, and are great wanderers over this part of the Archipelago. They build large and roomy praus with outriggers, and settle on any coast or island they take a fancy for. They hunt deer and wild pig, drying the meat; they catch turtle and tripang; they cut down the forest and plant rice or maize, and are altogether remarkably energetic and industrious. They are very fine people, of light complexion, tall, and with Papuan features, coming nearer to the drawings and descriptions of the true Polynesians of Tahiti and Owyhee than any I have seen.

Second, we have awareness of differential rates for mutation in sex-linked genes and non-sex-linked genes. It is unlikely, as we have argued above, given the complex morphological changes involved in the genetic selection for cold resistance, that the genes governing cold adaptation and famine resistance simply belong to the faster-evolving mtDNA and Y-chromosome parts of the genome, though as we have seen the evolution of famine resistance may involve some of these genes. The genetic evidence logically implies tens of thousands of years of exposure to the risks of hypothermia.

There are other arguments against Houghton's conclusion that Polynesian cold resistance developed rapidly in Island Melanesia, perhaps over only a few hundred years. The acknowledged Spice Island base for the Cinnamon Route seems geographically, economically, historically and genetically more likely than a base in Island Melanesia. The Spice Islands lay poised between two oceans just as for more than 30,000 years before the last Ice Age flood they had been poised between the two ancient continents of Sahul and Sundaland. Having had more than 30,000 years to have evolved cold resistance, already cold-resistant Spice Island mariners could have sailed the Cinnamon Route by the earliest date historians have proposed for its establishment (3,500 years ago, J. Innes Miller suggests [38]). In contrast to Island Melanesians, spice traders from the Spice Islands would have had an obvious motivation for colonizing Madagascar: the establishment of a spice-trading base close to the major African entrepot in Rhapta which had trading links to Egypt, Europe and Asia. (Genetic and linguistic evidence relating to the colonizations of Madagascar are discussed in Chapter 5.)

Houghton's physiological evidence and modern genetics suggest that the evolution of the Polynesian cold-adapted body type developed in response to millennia of exposure to life in an oceanic environment. If selective pressures are strong, mutation might well be faster, but a time scale of over 30,000 years may have been needed to allow for the evolution and coalescence of the mutations involved. In following chapters we suggest that evolution of cold resistance may have matched the evolution in spice trading from a local to a regional to an international level. Over time, increasing resistance to cold and famine would have made longer trading voyages possible. Longer exposure to the risks of hypothermia through longer voyages would in turn have promoted greater cold adaptation and famine resistance.

Archaeological evidence relating to the long maritime history of the Spice Islanders is understandably scant. In Chapter 3 we shall consider the available evidence. But first we must consider the oceanographic context needed for interpreting this evidence. To do so we turn to recent research in the field of palaeo-oceanography.

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Chapter 3
The Oceanographic Context

The West Pacific Warm Pool and the Evolution of Maritime Skills and Technologies in the Spice Islands

Abstract This chapter explores changing oceanographic conditions within the West Pacific Warm Pool from the Ice Age to the Holocene. We argue that Spice Island maritime history is linked to the tectonic and oceanographic history of the WPWP. Its high sea surface temperatures offered Spice Island mariners some protection against hypothermia over short distances in the Ice Age. In the mid-Holocene the strategy of following powerful warm currents flowing out of the WPWP gave Spice Island mariners some protection against hypothermia in ocean waters far outside the Pool and further reduced the risk of hypothermia by ensuring fast passages over long distances. This protection supported the Spice Islanders' eventual development of transoceanic exploration, trading and migration in both the Indian and Pacific Oceans.

Keywords West Pacific Warm Pool · Ice Age refuge · Early maritime trading · Mid-Holocene voyaging nursery · Current-based voyaging

3.1 The West Pacific Warm Pool

One of the major implications of Houghton's research on cold adaptation is that high sea surface temperatures would have been vital for prehistoric ocean voyaging – a prerequisite for exploration, maritime trading and migration. The history of changing sea surface temperatures in the ocean waters close to the Spice Islands is therefore relevant to understanding the trading and voyaging range possible for Spice Islanders at various stages of their maritime history. Temperature range and variation within what oceanographers call the West Pacific Warm Pool is of central importance here. Palaeo-oceanographers P. Martines, P. de Deckker and T. Barrows [1] have used deep sea cores to determine sea surface temperatures in the West Pacific Warm Pool (WPWP) at the Last Glacial Maximum 20,000 years ago. Using evidence from these cores, they mapped the summer and winter boundaries of the WPWP. (The boundaries move southwards towards the equator in winter.) Both Ice

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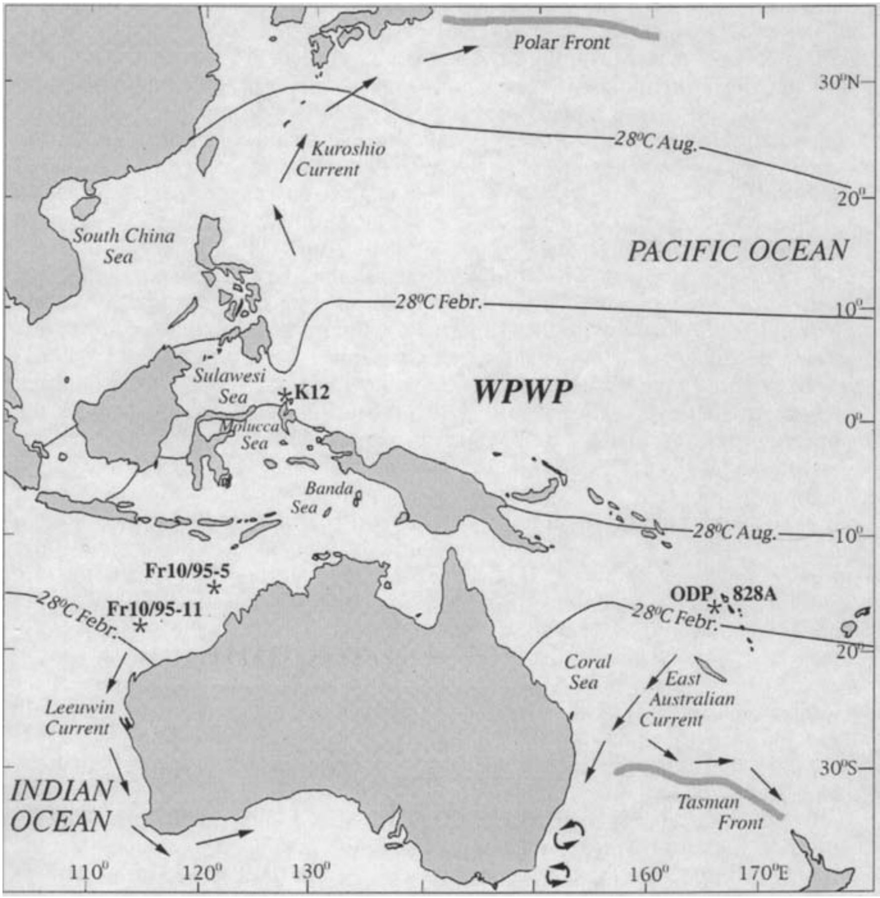

Fig. 3.1 Map of the western Pacific showing the limits of the WPWP (the 28°C isotherm) in August and February (from [1]). Reproduced with permission from Catena Verlag

Age and present-day boundaries are defined by a sea surface temperature (SST) exceeding 28°C. An adjoining region with an SST of at least 25°C is also defined. Comparison of the contracted Ice Age boundaries with the present boundaries of the WPWP is interesting (see Figs. 3.1, 3.2 and 3.3). While the present-day WPWP is possibly twice as large as the WPWP at the Last Glacial Maximum, temperatures within the Ice Age Warm Pool are believed to have been only 1–3°C lower than today's [2].

A deep sea core used to determine summer and winter SSTs in the Moluccan Sea at the height of the last Ice Age recorded surprisingly warm temperatures close to the Spice Islands. The reason for this is not just that the equator passes through Halmahera, the largest of the Spice Islands, but that even in the Ice Age when the WPWP was much smaller, the Spice Islands, according to season, either lay within or close to the southern boundary of the WPWP.

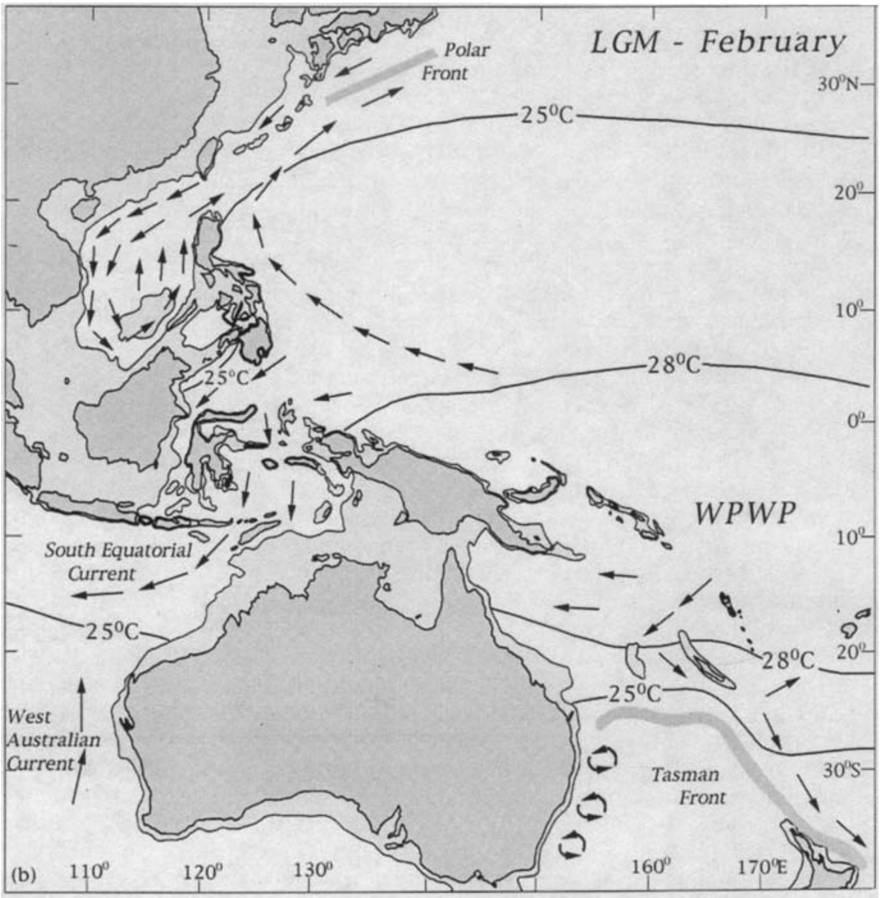

Fig. 3.2 Map of the western Pacific with a palaeo-oceanographic representation of the WPWP during the Last Glacial Maximum for the austral summer (February) (from [1]). Reproduced with permission from Catena Verlag

The significance of this fact for the history of maritime trading in the Spice Islands is clear: even at the height of the last Ice Age, Spice Island mariners had ready access to ocean waters with high SSTs. Houghton's research on cold adaptation shows the maritime advantage this would have given them.

In the northern hemisphere winter Halmahera and the northern Spice Islands actually lay within the WPWP, as did the northern third of Sulawesi and the part of the northern coast of the northern continent of Sundaland that now roughly corresponds to the northeastern coast of Borneo. But the north coast of New Guinea (which was then the north coast of Sahul, a continent including New Guinea and Australia), the Bismarck archipelago and the Solomon Islands lay outside it in a region defined by SSTs of over 25°C. In summer the situation was reversed: the Spice Islands, Sulawesi and the northeastern coast of Borneo lay outside the WPWP in a region with SSTs of 25°C, while the north coast of New Guinea and the

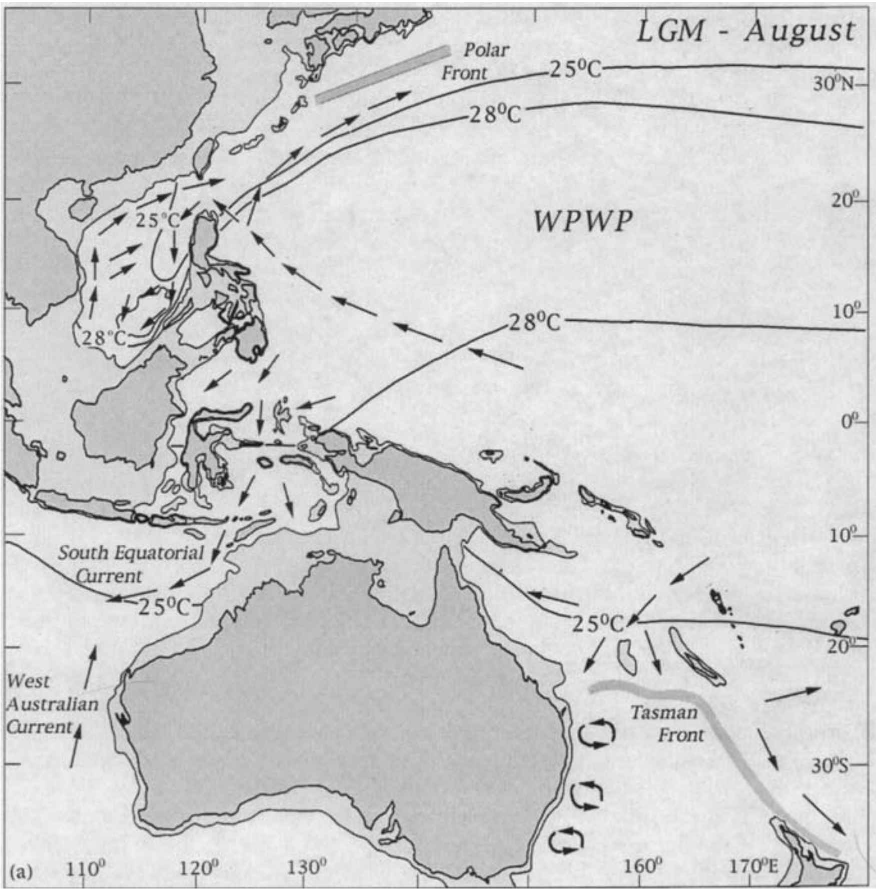

Fig. 3.3 Map of the western Pacific with a palaeo-oceanographic representation of the WPWP during the Last Glacial Maximum for the austral winter (August) (from [1]). Reproduced with permission from Catena Verlag

Bismarcks and Solomons and the northern part of Island Melanesia lay within the summer WPWP.

The changing seasonal boundaries of the WPWP would have defined likely trading areas for the Spice Islanders in the Ice Age. Given stronger winds and so a higher chill factor during the last Ice Age, a 3° difference in SSTs between the WPWP and surrounding region with SSTs of 25°C would have been constraining. In the northern hemisphere summer the Spice Islanders could have traded to the east, along the northern coast of New Guinea and with the Bismarcks and Solomons which in this season would have had SSTs exceeding 28°C. In winter Spice Islanders could have traded to the west with northern Sulawesi and the northeastern coast of Borneo which in this season would all have lain within the Warm Pool.

Throughout the Ice Age, maritime trading for the Spice Islanders and for any other coastal mariners in their immediate region would have been seasonally supported by the warm SSTs of the WPWP. But mariners sailing on bamboo rafts lying low in the water would have been continually exposed to wet and windy conditions. It has been estimated that winds were 30–70% stronger at the Last Glacial Maximum than today [3]. The chill factor would have been correspondingly greater, compounding the risk of hypothermia for mariners and generating selective pressures for genetic cold resistance.

Although other Ice Age maritime traders in the region may have shared the advantage of the high SSTs of the WPWP, the Spice Islanders had a geographical advantage. Their archipelago was poised between the two ancient continents of Sahul and Sundaland. The latter was a vast continental area which included what is now Island Southeast Asia and the Malaysian Peninsula and all the sea floor between. The Spice Islanders' pivotal position would have given them a trading advantage over their coastal neighbours to the east and to the west, for their trading journeys to Sahul or Sundaland would have been only half the distance of those for their eastern or western neighbours who would have had to travel the whole distance to or from Sahul to Sundaland. As the risk of hypothermia increases with distance, that is, with the length of exposure to cold, the Spice Islanders' pivotal position would have given them a significant physiological advantage. Although some of their neighbours may also have had long maritime histories, the Spice Islanders' long existence in an archipelago dependent for survival on inter-island trade and their possession of unique spices for trade may well have motivated an earlier maritime development. Though the Bismarck archipelago possessed an important trading resource in Talisean obsidian, none of the Spice Islanders' possible trading neighbours in New Guinea, the Bismarcks, Solomons and Borneo and Sulawesi, located in or close to the southern boundary of the WPWP, lived on spice-growing islands.

We shall argue that spice trading was fundamental rather than incidental to the maritime development of the Spice Islanders, that it was probably a driving factor in their evolution not only from local to regional trading but from regional trading to international maritime trading. And that it was fundamental to their evolution of the cold resistance and also of the horticultural skills and sailing strategies and technologies that enabled them not only to become long-distance maritime spice traders but also eventually to become the explorers and colonizers of the Pacific.

Palaeo-oceanographic evidence for high SSTs within the WPWP, making possible regional as well as local maritime trading even during the Ice Age, supports the likely antiquity of the Spice Islanders' regional as well as their local maritime history. It also highlights the central role played by the WPWP in Spice Island maritime history. As we have seen probably 11,500 years was needed for the evolution of the three defining sex-linked mutations, carried by Spice Islanders, coastal Papuans and Polynesians, which separate them from populations in Luzon, the Philippines and Taiwan. A still greater antiquity is implicit in the evolution of the slower non-sex-linked genes conferring on Spice Islanders the cold resistance and famine resistance that at various levels made possible the pursuit of spice trading at all stages in their maritime history. We argue that the Spice Islanders' evolution of genetic cold resistance and famine resistance was generated by the combined selective pressures of limited local and regional maritime trading over the long period of the Ice Age followed by the change to more challenging long-distance voyaging in the Holocene. Long-distance voyaging brought increased risks of hypothermia because the longer distances attempted meant longer periods of exposure to cold.

In this chapter we explore the changing oceanographic conditions within the WPWP from the Ice Age to the Holocene. Understanding these changing conditions is important for understanding how a maritime history encompassing 30,000 years of seasonally constrained limited trading in the Ice Age could have been so remarkably transformed by the possibilities presented by the global warmth of the Holocene and by the expansion of the WPWP made possible by this warmth.

3.2 The Oceanographic Functions of the West Pacific Warm Pool

The WPWP, also known as the Indo-Pacific Warm Pool (IPWP), has five major functions:

(i) It has the role of equalizing heat in the world's oceans and especially in the Indian and Pacific Oceans. In association with the meteorological phenomenon we know as the El Niño Southern Oscillation (ENSO), in warm climate periods it appears to have a role in dispersing heat from the planet.

(ii) It has a role in equalizing sea surface salinity in the Indian and Pacific Oceans and

(iii) a role in equalizing sea levels in these oceans.

All three functions are performed through the gathering and concentration of warm ocean waters in the WPWP in response to the west-flowing equatorial currents of the Pacific and through the dispersal of very warm waters from the WPWP into the Indian and Pacific Oceans.

(iv) The WPWP also has a globally significant role in driving atmospheric circulation. Indeed it is a primary component of the global coupled ocean–atmosphere system [4].

(v) It has an additional role with global implications, that of supporting or moderating ENSO events. This role appears to date back about 5,000 years. Donders et al. [5] speak of a mid-Holocene intensification of ENSO:

> The proxy data consistently indicate that a state change occurred at ~5 ka cal BP towards active ENSO cyclicity in the equatorial Pacific. Furthermore, from around 3 ka cal BP the ENSO-teleconnected regions are characterized by an increased impact of ENSO, comparable to the present-day high-amplitude fluctuations of ENSO.

The authors suggest that WPWP heat charging "is a possible explanation for the late-Holocene increase in ENSO amplitude".

The high SSTs and the size of the WPWP (estimated to be today comparable in area to the United States) go some way to explaining the significant role of the

Pool in global atmospheric circulation and its capacity for amplifying or moderating ENSO events. Because "radiative forcing changes have a large influence on ENSO dynamics, affecting global maritime distribution and oceanographic conditions", understanding the oceanographic history of the WPWP and its influence on ENSO variability has an important place in modern research as a means of predicting the role of the WPWP under conditions of global warming [6]. Understanding the complex roles of the WPWP and the history of changes within the Warm Pool, however, is also relevant for understanding the past. They reflect global climate change, affect ENSO amplitude and so are relevant to our specific concern: understanding the role of the WPWP's outflowing currents in shaping prehistoric oceanic exploration, trading and migration over millennia in both the Indian and Pacific Oceans.

3.3 The Major West Pacific Warm Pool Currents

Warm water from the WPWP is dispersed into the Pacific and Indian Oceans through four major currents flowing out from the Pool. The Kuro Shio Current drives northwards through Micronesia to Japan and then flows east to Hawaii and the southern coast of California. Turning south along the west coast of America it then turns west above the equator and, as the North Equatorial Current, travels back across the Pacific to the Spice Islands. A second major current flowing out of the WPWP forms a clockwise loop in the northern Indian Ocean, flowing west as the Equatorial Current to the east coast of Africa, turning north and flowing up this coast and then returning as the Indian Counter Current to Timor. A third major WPWP current, the East Australian Current, flows south parallel to the east coast of Australia before reversing direction in response to the landmass of New Zealand and then flowing north along the west coasts of the South Island and of the North Island. This current would have drawn canoes to a landing on the west coast of the South Island (the landing place recorded in traditional accounts of the earliest voyages to New Zealand). The fourth major current, the West Australian or Leeuwin Current, after the last Ice Age flood, reversed its direction to flow southwards along the west coast of Western Australia.

The first three of these four currents have major significance for a Spice Island-based Polynesian prehistory. The high SSTs of the WPWP offered Spice Island mariners some protection against hypothermia over short distances in the Ice Age. In the second half of the Holocene, adopting the strategy of following powerful warm currents flowing out from the WPWP gave Spice Island mariners some protection against hypothermia in ocean waters far outside the Pool and further reduced the risk of hypothermia by ensuring fast passages over long distances. As we shall see, this protection supported the Spice Islanders' eventual development of transoceanic exploration, trading and migration.

In this chapter we argue that the history of Spice Island maritime trading exploration and colonization is linked to the geological and oceanographic history of the

WPWP. We begin by considering early Spice Island maritime history in the light of the scant available archaeological evidence for maritime trading in the region in the last Ice Age and early Holocene. We then explore evidence for major geological and oceanographic changes to the WPWP in the mid-Holocene and show how these triggered significant changes in the range and scope of Spice Island exploration and trading activities, leading eventually to the Spice Islanders' discovery and settlement of the largest uninhabited islands in two oceans.

3.4 Early Evidence for Maritime Trading in the Spice Island Region

The Spice Islanders' maritime history was to a considerable extent determined by the unique geography and horticultural history of the archipelago in which they lived. Joanna Hall Brierley describes the Spice Islands as a "volcanic mini-archipelago of around a thousand islands". She comments that its islands seem to have been unusually interdependent, with Spice Islanders relying on inter-island trade for their survival. She notes that

> The early inter-island trade in Moluccan spices was linked to the primary food source of the islands, the sago palm *Metroxylon sagu*. This enormously productive palm provided essential food for the small, volcanic, inner islands of the Moluccan archipelago on which spices and coconuts were all that could grow. These inner islands profitably traded their spices for the sago grown on the outer islands of Halmahera, Seram, Kei and Aru [7].

With maritime trade integral to survival at a subsistence level from the first settlement of the inner islands, local subsistence maritime trading in the Spice Islands may have a time depth of close to 40,000 years. But living in an archipelago where rare spices grew in unique microclimates may have prompted very early development of the maritime skills and technologies appropriate to more extended regional trading. To find archaeological evidence dating back 30,000–40,000 years to establish this is, of course, improbable when dealing with the archaeologically fragile dried flowers and bark that we recognize as cloves and cinnamon.

The first evidence for regional maritime trading in the region dates back 33,000 years, an estimate for the time depth involved for the sea crossing to the Bismarck archipelago from Sahul [8]. This crossing has been taken to be a measure of early maritime sophistication and possibly also of evidence for early chert-trading. Patrick Kirch [8] comments that "The discovery of chert-flaking floors dated at 35,000–33,000 years ago at Yombon in the interior of New Britain (35 kilometres from the coast) dispels any simple notion that the Pleistocene colonists confined their activities to the shoreline." Exploration and an interest in tool-making materials to use and trade may have gone hand in hand.

Thirteen to fifteen thousand years later, that is 20,000 years ago at the Last Glacial Maximum, there is archaeological evidence that obsidian was being traded from the same area, the Talasea and Mopir areas of New Britain, to Matenbek and Buang Merabak, a distance of some 350 km involving a sea crossing [9]. That regional trading existed in the coldest phase of the Little Ice age, and that such a distance was being sailed then, provides a context in which we can consider the possibility that the Spice Islanders may have had a role as regional maritime traders by this time. At this date the Spice Islanders had already been archipelago dwellers, and at least local maritime traders, for 20,000 years. The Ice Age floods that were to drown Sundaland lay 7,500–12,500 years in the future. As the inhabitants for 20,000 years of an ancient island world, it is arguable, though not currently provable, that Spice Islanders may have expanded by this time from limited local trading to regional trading and even to have become involved with regional obsidian trading as well as regional spice trading.

The next evidence of obsidian trading, 7,000–12,000 years later, supplies clear evidence for Spice Island involvement with obsidian sources in the Bismarck archipelago. Archaeobiologists Elizabeth Matisoo-Smith and J.H. Robins [10] note that at Panakiwuk in New Ireland in the Bismarck archipelago, three bones of *Rattus exulans*, the Pacific rat, were recovered from levels dated to between 8,000 and 13,000 BP. As we have seen, this rat, which Matisoo-Smith and Robins have established has its origins in Halmahera in the Spice Islands, was carried into the Pacific with the Lapita peoples as a food animal. Its presence in the Bismarcks may mean that Spice Islanders had established a very early colony in the Bismarcks, associated with obsidian trading, or that Spice Island obsidian traders may have brought the rat to the Bismarcks and released it there to provide a permanent food resource for their people when carrying out future trading activities in the archipelago. In either case, the presence of the rat bones suggests a presence, and possibly a continuing presence, in this period of Spice Islanders in a region not only famous for its obsidian but already at this time possessing a 20,000-year-long obsidian trading history.

Obsidian and chert offer the earliest archaeological evidence of likely trading in the region. Regional spice trading was probably as ancient and as significant. But where obsidian, a hard black volcanic rock, survives to tell of its role as a trading commodity, cloves, nutmeg and cinnamon sticks have a short vegetable life. Their discovery is archaeologically improbable in contexts as ancient as those we have been discussing. That Spice Island mariners may have had a trading range as far as the Bismarcks by the late Ice Age or early Holocene is significant in its own right. It also supports the possibility of an earlier connection (though of course it cannot establish this).

The necessity for maritime subsistence trading in the Spice Islands dating back 40,000 years, the possibility of regional chert-trading 20,000 years after this and a probable Spice Island connection with obsidian sources in the Bismarcks 8,000–13,000 years ago suggest the possibility of a very considerable time depth for the Spice Islanders' maritime trading in the region. This might be of only incidental interest were it not for the fact that, as we have argued, a considerable time depth is needed to allow for the slow genetic evolution in the Spice Islands of the cold-adapted body type and famine resistance without which, Houghton's evidence makes clear, the Spice Islanders and their descendants could not have explored and settled the Pacific.

3.5 The West Pacific Warm Pool as a Long-Distance Voyaging Nursery

The next stage in the developing pattern of regional maritime trading and sophistication that we have been considering would have been expansion from regional trading over moderate distances to long-distance and international trading involving far greater distances. There is archaeological evidence that by 6,000 years ago such a progression had already occurred. We shall examine this archaeological evidence shortly. First, however, we focus on oceanographic evidence for a possible specific impetus for this change in trading range and maritime sophistication. The impetus belongs to a period at most only a thousand years before that suggested by archaeological evidence for the change to long-distance regional and international maritime trading. It appears that the trigger for a dramatic increase in maritime trading range and in the evolution of maritime technologies followed the last Ice Age flood 7,500 years ago, for there were dramatic changes to the WPWP after this flood. These changes appear to explain the archaeologically sudden evolution in the Spice Islands about 6,000 years ago not only of new maritime skills and technologies but also of new sailing and exploration strategies and boat design.

The maritime history of the Spice Islands in the last 14,000 years was shaped by catastrophic events. Three Ice Age floods, triggered by ice melt in the warmer conditions that followed the Ice Age, together raised sea levels by 120 m and completely changed the geography of the world in which the Spice Islanders had lived for over 30,000 years. As we have noted, before the last Ice Age flood 7,500 years ago, the Spice Islands lay between two ancient continents, Sundaland and Sahul (see Fig. 3.4). Sundaland, to the west of the Spice Islands, included Malaysia, Island Southeast Asia and Indo-China and all the lands between which now lie under the South China Sea, the Java Sea and the Gulf of Thailand [11]. Sahul to the east included New Guinea, mainland Australia and Tasmania. Wallace's Line, the deep ocean trench named after the English biologist George Wallace, separated the two ancient continents.

Sea levels had been rising globally since the continental ice sheets first began melting about 14,000 years ago. But 7,500 years ago the remainder of the vast Laurentian ice sheet broke up suddenly and sent ice crashing and driving into the Atlantic Ocean through the Gulf of St Lawrence in Canada. As huge islands of ice melted, world sea levels rose dramatically, reaching a level 120 m above that at the Last Glacial Maximum. Low coastal lands worldwide were submerged. Coastal cultures were destroyed as tidal waves were triggered by the shift of weight on the Earth's tectonic plates following the transfer of frozen water from land to sea. Great strips of the flat continental shelves along the coasts of China and Australia disappeared under the ocean. Sundaland was drowned. The higher land and mountain peaks of that ancient continent formed the archipelago of 17,000 islands we now know as Island Southeast Asia. Deluge legends worldwide record the catastrophic loss of life that followed this last flood.

In Australia aboriginal legends tell of the flooding of Bass Strait which now separates Tasmania from the mainland; from Mesopotamia we have flood stories centred

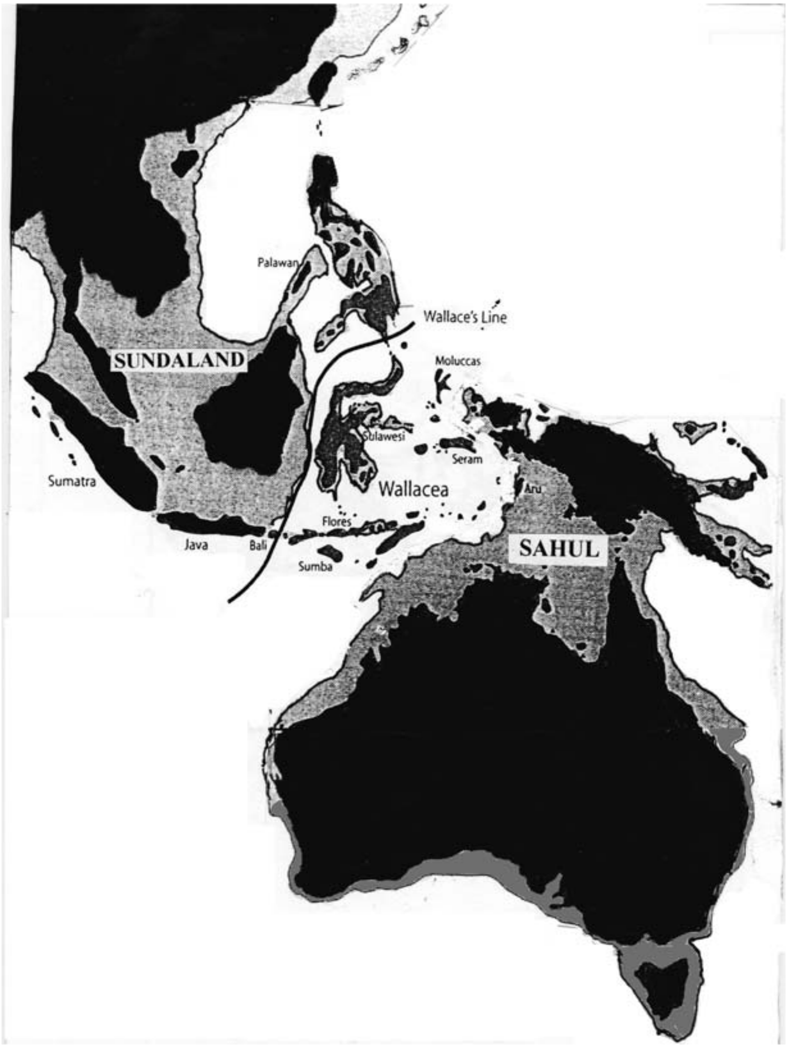

Fig. 3.4 The ancient continents of Sahul and Sundaland. Modern topography is shown within the ancient continental boundaries

on the hero Gilgamesh; there are American Indian flood legends; and, in western culture, memory of the last Ice Age flood survives in the biblical story of Noah and his ark. Given the dramatic consequences of this ocean flood in Island Southeast Asia, it is hardly surprising that, as Oppenheimer tells us, "The Austronesian speakers of Southeast Asia and the Indo-Pacific region have more flood stories than peoples of any other single language phylum" [12]. Nor is it surprising that the biblical story of Noah was already known in Polynesia before European missionaries arrived.

Between 7,000 and 5,000 years ago, as a possible long-term consequence of the tectonic disturbances that followed the last Ice Age flood, undersea volcanic activity in the West Pacific Warm Pool led to an astonishing increase in SSTs within the Warm Pool between the Spice Islands and Japan. As early as the 1970s the pioneering climate historian H.H. Lamb [13] noted that

> Examination of corals and mollusk shells on raised beaches in Japan, radiocarbon dated 7000 to 5000 years ago, suggests (Taira 1975) that the Kuro Shiwo (warm North Pacific Current) had about the same northward extent as today but was between 2 and 8°C warmer than today. The smaller values of water temperature anomaly were apparently derived by species examination, the larger values by oxygen isotope measurement – a middle value of 5°C warmer than today may be realistic. Crustal movements in Japan and further south are suggested by Taira as partly the cause of the subsequent change of the current and the prevailing temperatures in it, since the supposed explanation is that the warm water current reaching Japan in the warmest postglacial times was drawn from farther south, from the ocean areas just north of Papua New Guinea that are still the warmest in the world – present-day mean 29–30°C.

Geoffrey Irwin's concept of a safe "voyaging nursery" in the cyclone-free corridor between the north coast of New Guinea and the Bismarcks and Solomons has received considerable attention. His idea is of a voyaging nursery which promoted the early evolution of the maritime skills and technologies needed for the Lapita peoples' exploration and colonization of the Pacific [14]. Atholl Anderson [15] has challenged this concept, arguing that there are other cyclone-free areas to the west which might have been equally useful and that "small-craft sailors adapt quite easily to predictable cyclone seasonality". But Irwin's concept of a voyaging nursery can be defended even if the area he delineates for the nursery may be harder to defend. As mentioned in the Introduction, we propose an earlier and far more extensive voyaging nursery, the WPWP stretching north from the Spice Islands through Micronesia towards Japan. This area is unique. Its most remarkable characteristic is not that it is cyclone-free but that it possesses the warmest ocean waters in the world and that at some time between 7,000 and 5,000 years ago its SST was perhaps as high as 35°C.

Higher SSTs in the WPWP allowed long-distance voyaging in exposed sailing rafts with less risk of death from hypothermia for their crews. Volcanically heated waters provided a voyaging nursery in which long-distance voyaging on bamboo rafts was safer than it would have been anywhere else in the world, perhaps at any time. Extraordinarily high SSTs provided a safety net as well as the impetus and opportunity to develop skills relevant to both long-distance trading and ocean voyaging. And they provided the opportunity, through the impetus of long-distance voyaging, for Spice Islanders to genetically acquire the further level of cold adaptation needed for it to be physiologically possible for them later to extend long-distance voyaging into the cooler waters of the Indian and Pacific Oceans. Favourable conditions in the West Pacific Warm Pool seem also to have prompted experimentation leading to the development of ocean-going double-outriggers and perhaps further experimentation in the use of sail. Combined, improved maritime skills and a higher level of cold resistance, following experience in the West Pacific

Warm Pool long-distance voyaging nursery, appear to have made it possible for Spice Islanders to advance from regional trading to long-distance maritime spice and plume trading in the northern Indian Ocean – probably initially in coastal trading to the Malabar coast of India and via Mesopotamian and Arabian coasts to ports in the Red Sea from where their spices could be taken overland to Syria and Egypt.

The evidence for the volcanic heating of the WPWP, which Lamb cites as following the last Ice Age flood and which he dates to between 7,000 and 5,000 years ago, may have been associated with the development "around 5,000 years ago" of "the modern ENSO recurrence and associated upwelling regimens" that Donders et al. describe as causing environmental change in the WPWP and present-day teleconnected areas [16]. The increased amplitude of ENSO events between 5,000 and 3,000 years ago suggests the persistence after 5,000 BP of a significantly enlarged Warm Pool and of high SSTs within it.

The increased amplitude of ENSO events on the cusp of major climate change about 3,000 years ago is interesting. It may have supported some of what we shall describe as "first-wave" voyaging activity taking place between 3,600 and 3,000 years ago: notably the west–east Lapita settlement of Island Melanesia and Western Polynesia (which may have exploited El Niño reversals of winds and currents) and the colonization of New Zealand. (The voyage south to New Zealand from the Spice Islands following the East Australian Current was possibly supported by an El Niño northerly.) But it is clear that while strong El Niño winds might have supported faster long-distance current-driven voyaging, El Niño support was additional rather than fundamental.

Local and regional maritime trading during the last Ice Age would have been supported by the high SSTs of the WPWP. Such trading would, however, have been limited by the greater chill factor associated with the colder and stronger Ice Age winds and the reduced size of the WPWP. International long-distance maritime trading belongs to the warmer mid-Holocene, supported by higher SSTs in the WPWP, probably in some instances by useful El Niño winds, by the doubled ocean area of the Warm Pool and by additional volcanic heating of the Pool. The global cold period between 1000 BC and 400 BC effectively removed the conditions that had made long-distance maritime exploration, trading and migration feasible before 1000 BC. The same limitations recurred nearly two and a half thousand years later during the Little Ice Age which ended prehistoric voyaging to New Zealand.

The WPWP can perhaps best be thought of as a dynamic phenomenon, its boundaries changing seasonally and, within a longer time frame, the size of the Pool itself changing in response to global warming and cooling. Its defining temperature as one exceeding 28°C makes possible its role in driving global atmospheric circulation, for it is when SSTs exceed 28°C that vigorous atmospheric convection begins. Given the strength and warmth of its major outflowing currents, it is hardly surprising that three of these currents could exert a powerful influence on maritime activity in the region. But it would have been far from trivial for prehistoric mariners to take advantage of the warmth of the WPWP and the strength of its currents. A long tradition of maritime trading, a cumulative acquisition of maritime expertise and technologies and the evolution of genetic cold resistance might be thought of as minimal prerequisites. It is arguable that for the Spice Island ancestors of the Polynesian peoples a 35,000-year maritime history which was lived on the borders of this changing and dynamic oceanographic phenomenon made possible the startling change to transoceanic voyaging after the last Ice Age flood. Their mastering of fast currents within the WPWP, thought of as a long-distance voyaging nursery, eventually made it possible for them to follow three of its major currents into waters outside the Pool. The skill and daring of Spice Island mariners and their readiness to seize new opportunities, matched to evolving cold resistance and dynamic changes in the WPWP itself, made possible the maritime feats we consider in the following chapters.

While in the late Holocene El Niño northerlies could assist voyaging from the Spice Islands to New Zealand and monsoonal winds could assist sailing of the Cinnamon Route, these advantages were supportive rather than fundamental. For prehistoric long-distance voyaging global warmth was an essential requirement. Only then was current-driven and El Niño-assisted transoceanic voyaging feasible.

Clearly, without the powerful WPWP currents that made transoceanic voyaging possible in global warm periods, Spice Island mariners would have been restricted to slow coastal trading. The warmth of the Holocene, the consequent enlargement of the WPWP and increased warmth of its major currents, due to volcanic activity on the sea floor, contributed to the Spice Islanders' evolution from regional and international coastal trading to international transoceanic trading. Being able to exploit three major WPWP currents transformed Spice Island maritime exploration, trading and migration history. We sketch the stages of this transformation in the following sections.

3.6 Spice Island Expansion from Regional to Long-Distance Trading After the Last Ice Age Flood

There is archaeological evidence for the expansion from regional to long-distance and international trading in the Spice Island region about 6,000 years ago. This evidence could be seen as supporting our claim that Spice Island mariners developed new skills and technologies within their WPWP voyaging nursery. Oppenheimer [17] points to evidence that, 6,000 years ago, obsidian was being traded from both the Lou Island near Manus and from Talisea in New Britain to Bukit Tengkorak on the east coast of Sabah in Borneo, 3,500 miles to the west. Lou Island obsidian had previously been found in Sabah dated to the Lapita period. But the radiocarbon date for the layer in which Malaysian archaeologist Stephen Chia found some 200 obsidian flakes from Lou Island and Talisea was 2,500 years earlier. This evidence suggests that maritime traders may have been engaged in long-distance obsidian trading from New Britain to Sabah as early as 6,000 years ago and that they may have continued in this role for another 2,500 years. Of course, we cannot claim that Spice Island mariners were responsible. But that they may have long been engaged in this trade is supported by the Spice Islanders' probable connection with obsidian trading 13,000–8,000 years ago and also perhaps supported by the Lapita peoples' moving into the Bismarcks after the Mount Witori eruption 3,600 years ago, possibly to secure the trade resource of Lou Island and Talisean obsidian which, Spriggs [9] argued, they were soon trading over the 8,000 km from Sabah to Fiji.

The claim for obsidian trade reaching from Lou Island and Talisea to Sabah in Borneo 6,000 years ago fits sensibly with other evidence for long-distance trade in the same area and era. It is relevant to remember that the proportion of the long-distance maritime trade in the area for which there is archaeological evidence may be miniscule. To what extent Spice Islanders were responsible for such trade, or for trade for which we have no evidence, is unguessable. Halmahera is known to have had an ancient plume trade in red parrot feathers. It is possible that about 6,000 years ago the Spice Islanders sought to extend their plume trade to Asia by accessing Bird of Paradise plumes from the New Guinea highlands through the Sepik River area. A 5,800-year-old betel nut (an Asian narcotic plant) found in a midden at Dongan in the Sepik/Ramu area of New Guinea supports Pamela Swadling's claims for ancient trade links between New Guinea and Asia, based on trade in Bird of Paradise plumes. And she suggests that the pre-Lapita development of incised and applique pottery in the Sepik/Ramu area, and more definitively further to the west, was associated with the plume trade [18]. She points to the fact that J. Roder found early incised and applique pottery at the base of his excavation at Dudumunir cave on Arguni Island, on the Onin coast of Berau Bay, in Irian Jaya and she comments that "Ian Glover considers this pottery to be comparable to the 5000 BP ware found in Timor."

Swadling's argument that the pottery found in Dudumuni cave was associated with the plume trade seems partly to be based on the fact that this area was such an important source of plumes both during the period of Asian trade and during the European plume-hunting boom of the early 20th century.

Swadling draws attention to the presence in the Sepik/Ramu area 6,000 years ago of an inland sea accessible from the north New Guinea coast, which would have facilitated trade between those living on the coasts of this inland sea and the highlands beyond, where Birds of Paradise were to be found. This inland sea would have given long-distance maritime traders ready access to plumes for trading to Asia. That such trading occurred is shown not only by the betel nut in the Dongan midden but also, Swadling implies, by the production of incised and applique pottery presumably needed to protect plumes in transit.

Although there is no direct evidence of Spice Island involvement in this trade, as we shall see in the next section, there are certainly strong suggestions of Spice Island connections with the Sepik/Ramu area. At the very least, evidence for long-distance maritime coastal trading with Mesopotamia from the region stretching from Borneo to the Sepik/Ramu area provides a context which makes long-distance spice trading from the Spice Islands with Asia probable in this period.

3.7 International Spice Trading

Clear archaeological evidence for a Spice Island-based international spice trade can only be dated to 1721 BC.

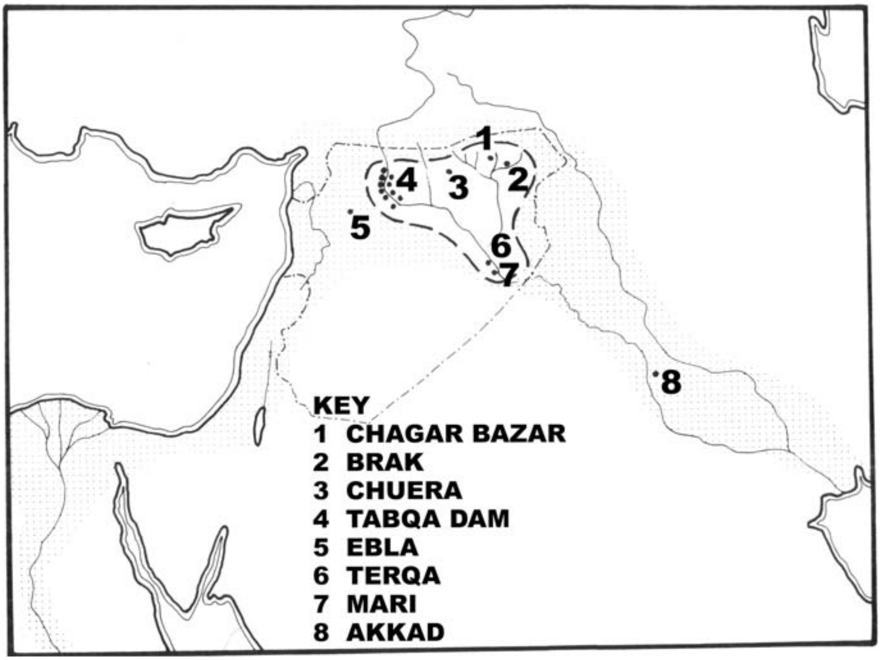

Fig. 3.5 Map showing the location of the ancient city of Terqa

But the Spice Islanders' spice trade with Mesopotamia, Syria and Egypt was probably as old as, or older than, evidence for the presence of cloves in Terqa. 1721 BC is the date (based on dynastic evidence) given to the handful of cloves found with other spices in a pottery jar in the pantry of the house of Puzurum in Terqa, an ancient city in Syria on the Euphrates River. See Figs. 3.5, 3.6 and 3.7. Figures 3.5 and 3.6 appear in [19] and Figs. 3.6 and 3.7 in [20]. We acknowledge permission from Undena Press and the Near East Archaeological Society to reproduce material from [19, 20] respectively.

Though the excavation of Terqa began 30 years ago, the final field reports are still being published by the White-Levy Program of Harvard University [21]. Terqa in Syria, a complex, autonomous, urban civilization, lies at the heart of the Fertile Crescent, buried under 60 ft of silt and cultural deposits. The ancient town dates back to the fifth and fourth millennia BC. It sits on 60 acres of land surrounded by three concentric, solid masonry walls, with a 60-ft-wide moat encircling the outer ring. Radiocarbon dating has established an age of 5,000 years for the walls, which were meant to repulse floods as well as invaders. Numerous clay tablets reveal something of the history of the town. Foreign artefacts demonstrate Terqa's connections to other civilizations. For example, eight scarabs found in the Temple of Ninkarrak may be the earliest evidence of Egyptian contact this far east. A Hittite stamp seal was found near a child burial in the higher level of Puzurum's house and may have

Fig. 3.6 A photograph from the excavation of Terqa showing the location of the small, upside-down, scarcely visible jar (marked by an *arrow*) which contained spices nearly 4,000 years old

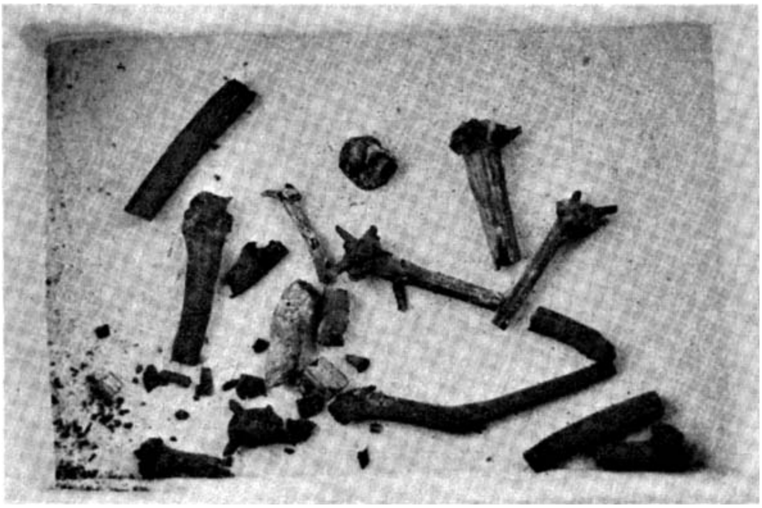

Fig. 3.7 A photograph showing the carbonized spices found inside the jar shown in Fig. 3.6

been left behind by Hittite troops on their way to sack Babylon in 1596 BC. The excavators comment

> The historical picture drawn by the texts and artefacts makes Terqa a type site for an essential period in the development of the ancient Near East. Since it was at the hub of a large

communication network which linked the arms of the civilized world, it was identifiably in contact with distant lands [21].

Specifically that contact, direct or indirect, included the Spice Islands. In the pantry of a small private house in Terqa, belonging to a land agent, Puzurum, a handful of cloves was found with other spices in a pottery jar. These cloves can only have come from the Spice Islands, for until the 16th century AD, the five tiny island of Tenate, Tidore, Mutir, Machian and Bachian, which lie off the west coast of Halmahera, were the sole source of cloves. That cloves were being used for cooking by a middle-class family in Syria in 1721 BC suggests that by this date spice trading to Syria was well established and was probably far older.

3.8 Ancient Spice Island Trading and Cultural Links with Mesopotamia and the Sepik/Ramu Region of New Guinea

There is evidence of cultural interactions between the Spice Island region and Mesopotamia, also on the Euphrates River but far to the south of Terqa, that predates the age of the Terqa clove by some thousands of years. For example, as Oppenheimer [22] points out:

> There is one distinctly Austronesian trait that appears in the early ‘Ubaid ceramics found under, and in graves let into, the silt layer at Ur. This is the tattooing of the female figurines. . ..There are paint marks and implants of clay pellets around the shoulders, suggestive of tattooing and skin scarification. Tattooing is a widespread Austronesian practice, but skin scarification has a more limited distribution in Oceania. The inhabitants of the Middle Sepik area on the north coast of New Guinea still practice this custom. Although these people do not speak an Austronesian tongue, they have extensive cultural borrowings. In some villages patterned scarification of the shoulders and torso is performed as an initiation rite and imitates the teeth marks of crocodiles. The resulting raised, patterned oval keloid scars resemble those of the ‘Ubaid figurines.

Oppenheimer notes also that

> Woolley noted with surprise the nature of the graves in which these figurines were found. Rectangular in shape, the base of the grave was carpeted in deliberately shattered pottery. The bodies were extended, unlike later burials and were also powdered in red haematite (iron ore). One body had an extra lump of red haematite and another statuette had its face painted bright red. A bracelet of shell beads was found around one wrist. The custom of painting extended bodies with haematite is also seen in wooden box burials from Niah Cave in Borneo. The earliest date for these box burials is 3800 BC.

Oppenheimer adds that the grotesque figurines found in the graves in Ur are still being carved in wood along the north coast of New Guinea.

The two forms, tattooing and scarification, are related to skin colour. Tattooing requires a fairer skin for the colour contrast on which tattooing patterns depend, but scarification, based on patterned scar tissue, does not depend for effect on skin colour. There are 19th century European accounts of scarification in New Zealand practised by Maori women at their husbands’ funerals, collected by Elsdon Best [23]. And Best mentions a traditional account of scarification practised by Kupe’s daughters, Mohuia and Tokahaero, who lacerated themselves, sorrowing over their father's absence in the South Island where he had gone to kill the giant octopus, Te wheke-o-mutu-rangi. Their blood stained a rock at Te rimupapa, which is still known as Mohuia after Kupe's daughter.

It is an intriguing fact that Maori curvilinear tattooing patterns and wood-carving patterns are unlike any others in Polynesia yet resemble those of the Sepik/Ramu region of New Guinea. This similarity may have its origins in ancient Spice Island trading links with the region. The preservation of ancient patterns is perhaps most likely to have occurred if New Zealand (as we shall argue in Part II) was colonized early and directly from the Spice Islands. Independent evolution of the same patterns is, of course, a possibility and, if this is the case, would suggest both significant time depth and long isolation for the descendants of the first colonists in New Zealand.

The links in curvilinear tattooing and wood-carving patterns and in the practice of scarification may support the possibility that a Spice Island colony was established in the Sepik/Ramu area 6,000 years ago when an inland sea existed and made possible trade with the highlands, the source of Bird of Paradise plumes. Of all highland language families, the Engan family (which consists of languages spoken in Enga and in the neighbouring areas of the East Sepik and the Southern Highlands provinces) has the largest number of Austronesian loan words [24]. The inland sea was converted to marsh about the time of the first Lapita migrations and there is a suggestion that some people from this area were forced by the changing conditions into migrations at this time and that others may have joined local non-Austronesian tribes and adopted their languages.

All of this suggests that long-distance maritime spice and plume trading from the Spice Islands and the Sepik/Ramu area of New Guinea may well have been practiced 6,000 years ago. The betel nut from the Sepik/Ramu and the 'Ubaid figurines are both dated to 5,800 years ago. That some at least of this trade was carried out by cold-adapted Spice Island traders seems probable, since Atholl Anderson [15] claims a later date for cargo ships sailing between the Middle East and India and does not suggest their penetration of Island Southeast Asia.

Despite increasing genetic evidence for an indigenous Spice Island or Wallacean ancestry for the Lapita and Polynesian peoples, the obvious connection between this ancestry and the maritime trading history of the Spice Islands has not been made. Once this connection is considered, the possibility that the Polynesians' ancestors were indigenous long-distance spice traders seems natural. Who more likely than the Spice Islanders themselves to trade the cloves that grew uniquely on the five tiny clove-producing islands off the western coast of Halmahera, and to trade nutmeg, cinnamon and mace from the Banda islands in the southern Moluccas?

The evidence presented above suggests that the Spice Islanders had probably been long-distance and international maritime traders for thousands of years before they began to explore and colonize the Pacific. For, as we have seen, there is a clear archaeological connection of Spice Islanders 13,000–8,000 years ago to obsidian sources in the Bismarcks, possibly evidence of their trading obsidian to Sabah from Lou Island and Talisea 6,000 years ago, and certain evidence of international spice trading in the discovery of the Terqa cloves available to a middle-class family in Syria nearly 4,000 years ago. Possessing control of, or access to, cloves, unique to the Spice Islands, we believe, would have been a strong motivation for the Spice

Islanders to become international maritime traders at a time before Phoenician and Indian maritime traders had taken control of the coastal sea route from the Middle East to Island Southeast Asia. In the earlier period the source of the Moluccan spices would, of course, have been kept secret to preserve the Spice Islanders' monopoly, in accord with ancient trading practices that also preserved the secret of the frankincense groves of Arabia.

If maritime spice and plume traders from the Spice Islands could have been reaching Mesopotamia 6,000 years ago, it is hardly surprising that the Spice Islanders were sailing as far as ports in the Red Sea 2,000 years later. Indeed, there seems no good reason that Spice Island cloves and other spices could not have reached the Fertile Crescent and Egypt far earlier than the period established by the find at Terqa. Mummification was being practised in Egypt at least 5,000 years ago. If there were an early Egyptian demand for cloves and cinnamon, antiseptics which were later of major importance for embalming, this may well have prompted Spice Island traders to sail the coastal route to the Red Sea far earlier than we can expect to find evidence that could establish this as fact. It is so improbable for the cloves found at Terqa to have survived intact for nearly 4,000 years, in a city buried under 60 ft of silt, that we can hardly expect still earlier evidence of the same kind elsewhere. If the Spice Island traders could reach the Euphrates delta 6,000 years ago, there seems no good reason for them not to have followed the coastal route from there to the Red Sea ports giving access to the Fertile Crescent and Egypt. For it is clear from recent evidence that Mesopotamian bitumen-coated reed sailing boats made from bundled reeds traded along this route 7,000 years ago [25].

3.9 Evolution of the Sailing Strategy of Following Fast Warm Currents over Long Distances

We have been considering evidence for the Spice Islanders' extension from regional trading to international spice trading with the development of maritime long-distance coastal trading through the northern Indian Ocean probably 6,000 years ago. But of greater significance was the Spice Islanders' development in the same period of a capacity for transoceanic sailing, based on their exploiting powerful warm currents flowing through and out of the WPWP. The development of this new capacity, we suggest, depended on their mastering, in what we have described as their WPWP long-distance voyaging nursery, of the sailing strategy of following fast warm currents over long distances. We shall argue that the evolution of this sailing strategy and the linked evolution of the double-outrigger as a craft optimally designed for exploiting fast currents together led to a remarkable extension in maritime skills and technologies and trading range. Indeed, we shall argue that it eventually empowered Spice Island mariners to become explorers, international horticultural traders and colonizers in two oceans.

Understanding the hydrodynamic advantages of the double-outrigger over the sailing raft that preceded it and the single-outrigger that replaced it in the central Pacific is important for appreciating its place in the Spice Islanders' adoption of the strategy of following fast currents. Their evolution of the double-outrigger ultimately made possible their progression to transoceanic sailing. (We wish to acknowledge the help given us by the late Ernie Tuck, ship hydrodynamicist, personal communication, in clarifying the relevant ideas.)

Sixty thousand years ago bamboo rafts may have carried the first peoples of New Guinea and some of the earliest ancestors of the aboriginal peoples of Australia from Sundaland to Sahul via Halmahera. Twenty thousand years later bamboo rafts may have carried the first settlers to the Spice Islands. Bamboo, which grows readily in Island Southeast Asia, is a remarkably useful material for raft construction. It contributes weight (giving the raft stability), buoyancy (air chambers in its stems make the raft unsinkable) and constructional flexibility, enabling the raft to ride relatively smoothly through rough ocean waters. Experiments conducted in Indonesia by Alan Thorne [26] showed that a bamboo raft could be constructed in a few hours, that it was "surprisingly easy to steer and control" and that it "moved freely along at four or five knots". Recent evidence that *Homo erectus* reached Flores by a series of sea crossings, the longest of which was at least 20 km, suggests the possibility of an astonishing antiquity for bamboo rafts in the region. Steve Webb suggests their antiquity may be as great as 750,000 years [27].

Salt water rafts, sailing rafts (made from wood rather than bamboo) and reed boats and reed rafts existed in prehistoric Polynesia and down to modern times. Where little wood was available, as in Easter Island and in the Chatham Islands east of New Zealand, reed rafts were the only choice. The Chatham Island reed rafts were beautifully crafted and sophisticated, using the buoyancy of sea-kelp to improve flotation. They are said to have been able to carry 60 persons between islands. A long, varied and extensive use of rafts throughout Polynesia suggests a cultural familiarity and expertise that could perhaps reach back to their ancestors' arrival in the Spice Islands on rafts 40,000 years before.

In following a fast current, a bamboo sailing raft would have distinct advantages. With its whole area in contact with the water, the propulsive power of the current would be optimally transferred to the raft. However, it would require a large area of sail to be able to make any headway against a contrary current because its drag coefficient would be so high. In the Indian Ocean where the Equatorial Current forms a continuous loop with the Indian Counter Current, a straightforward return journey from the Spice Islands to Africa was possible. A sailing raft would have been able to handle the Cinnamon Route. In the West Pacific Warm Pool a raft could have followed the Kuro Shio Current from the Spice Islands through Micronesia to Japan, but the return journey to the Spice Islands would have been difficult. In order to return to the Spice Islands the raft would have to sail south just beyond the reach of the current, perhaps travelling outside its western edge past the islands of Oshima and Okinawa and down the western coast of the Philippines. It would probably have to make several stops to wait for favourable wind conditions and all the way the wind power of the sails would have to fight the drag of the raft.

For a return journey which is only supported one way by a strong current, a double-masted Halmaherian double-outrigger would be a far better choice. Having three points of contact with the water (through the hull and two outrigger beams) would allow for good transference of the propulsive power of the current to the canoe on the outward journey with two balanced outrigger beams to give it optimal stability in a fast current. With reduced drag, in comparison with a sailing raft, because of the lightness of the double-outrigger and its reduced area of water contact, the return journey without the support of a current could be made under wind power.

Haddon and Hornell [28] claimed that the double-outrigger was replaced in the Pacific because the single-outrigger was more seaworthy. This remark ignores the differential advantages of single- and double-outriggers in different ocean conditions. The double-outrigger has better balance and seaworthiness, a speed advantage in following fast currents and an advantage over a sailing raft in a situation where it cannot call on the propulsive force of a current. But the single-outrigger has the advantage when using wind power as the primary means of propulsion. Having only two points of contact with the water it has less drag, and so a more immediate response to the power of the wind. When wind is the primary means of propulsion, it is possible to remove a second outrigger and still preserve adequate stability, though such a craft is in fact less stable and so inherently less seaworthy than a double-outrigger. Mariners would have to continually exercise care to ensure their weights were evenly distributed, given that a heavy hull and one light outrigger beam are unevenly balanced.

The universal use of double-outriggers in the southern Indian Ocean over the last 3,000 years is only to be expected when currents conveniently provide a continuous return journey loop from one side of the ocean to the other. The near-universal use of single-outriggers in the southern Pacific Ocean is also predictable, for in the southern Pacific currents and winds are contrary for west–east sailing and often light and unpredictable. There wind power is the obvious option and the single-outrigger the obvious choice.

That double-outriggers emerged in Wallacea after the last Ice Age flood amongst mariners operating in the WPWP region and that they have survived till today not only in the Indian Ocean and on the east coast of Africa but in Island Southeast Asia suggests the importance of this technological development for long-distance as well as inter-island trading. The development of the double-outrigger meant the development of a flexible craft with great stability, able to handle and exploit the power of fast ocean currents but also able to use wind power at need. We shall argue that its development was of key importance not just for the pioneering of oceanic voyaging within the WPW but also, considerably later, for the Spice Islanders' exploration and colonization of the Pacific and southern Indian Oceans using the strategy of following major fast warm currents flowing out of the WPWP.

3.10 The Early Settlement of Micronesia

We have sketched the oceanographic background to the Spice Islanders' long maritime history in their own region and to their evolution from local to regional to long-distance trading. We conclude by considering evidence for a very early settlement in Micronesia. We discuss the possibility of related spice trading with Japan and consider the possibility that Spice Islanders may have established a very early Spice Island colony in southern Japan. These possibilities are very much in keeping with the logic of Spice Island maritime history as we have portrayed it. They emphasize both the importance of spice trading and the central place that the WPWP played in that history.

Just how important a role the WPWP played, not only in the Spice Islanders' development of maritime skills and technologies but also ultimately in their exploration and colonization of the Pacific and southern Indian Oceans, will become clear in subsequent chapters. Here we draw attention to the simple possibility that Spice Island traders may have exploited the southern extension of the Kuro Shio Current, which appeared between 7,000 and 5,000 years ago within the WPWP, in order to establish spice trading with Japan and to set up an early spice-trading colony or base there. This possibility is more fully explored in Chapter 5. We suggest that they may have established early settlements in Micronesia as rest and supply stations for this trading route.

The doubling of size of the WPWP as a result of the global warmth of the Holocene, its anomalously high SSTs caused by volcanic heating, the consequent southerly extension of the Kuro Shio Current and the persisting economic motivation of spice trading all support the possibility that the first major WPWP current to be exploited for oceanic trading by the Spice Islanders was that part of the Kuro Shio Current flowing through Micronesia to Japan. The strongest evidence for this is a very early first settlement date for Micronesia. Palaeo-environmental evidence suggests that the island of Ngerekebesang in Palau may have been first settled about 5,700 years ago [29]. It is probably no coincidence that the dating for this matches the estimates for the volcanic heating of the WPWP between 7,000 and 5,000 years ago, creating SSTs possibly as high as 35°C.

Given powerful economic motivation for establishing spice trading with Japan and perhaps through Japan with coastal China, it is perhaps not surprising to find the earliest date for the first settlement of western Micronesia predates the colonization of the Bismarcks and Solomons, Island Melanesia and Western Polynesia by at least two millennia. The extraordinarily warm temperatures in the volcanically heated WPWP at this time made long-distance voyaging to and through Micronesia feasible. It is probably not coincidental that Palau, only about 900 km from the Spice Islands, is a natural stopping place en route to Japan through Micronesia.

Japan would have been an obvious market for spices and may even have acted as a base for supplying spices to a wider Asian market. Chinese traditional medicine appears already at this date to have been sophisticated: the presence of acupuncture tattoos on the famous 5,000-year-old "Ice Man" found in the Italian Alps suggests the diffusion to Europe already by this date of a complex Chinese medical system. Korea and Japan today preserve and practise ancient medical systems related to and probably derived from ancient Chinese medicine. The usefulness of the clove as a local anaesthetic and aphrodisiac, and the cinnamon and clove as antiseptics, suggests a wider market for spices than as a condiment and supports the possibility of a medical market for spices in Asia 5,000 years old. Just as the earliest palaeo-environmental evidence for the first settlement of Palau predates the earliest archaeological evidence by 2,300 years [30], so we might well expect that reliably dated archaeological evidence for the earliest coastal spice trading with Egypt and Asia from the Spice Islands may well lag behind the true dating by millennia.

In Chapter 5 we outline the considerable evidence (craniometric, cultural, archaeological, linguistic and genetic) presented by Ann Kumar and Phil Rose [31] for the establishment of an Indonesian colony in Japan in the Yayoi period (300 BC–AD 300). But the possession of shared mitochondrial markers between Japanese and Indonesian women, which Kumar records, suggests a far more ancient contact between the two countries than that implicit in a later Yayoi colony. Given the time needed for coalescence, a far earlier colony is needed to explain the genetic evidence. The Indonesian contribution of Japanese mitochondrial DNA suggests not just trading visits by male mariners but a permanent early settlement and a long period of intermarriage with an established Japanese population. (The presence over a long time of only Spice Island male traders would have had no effect on Japanese maternal DNA.)

In this chapter we have suggested that the volcanic creation of a voyaging nursery in the WPWP, possessing extraordinarily high SSTs, allowed Spice Island mariners to develop skills and technologies relevant to long-distance voyaging with far less risk of hypothermia. Here we add the possibility that the motivation for mastering long-distance voyaging within the WPWP may have been driven by the possibility of their establishing spice trading with Japan, and perhaps through Japan with Asia. The setting up of transoceanic voyaging in the Indian Ocean, perhaps 1,500 years later in the reign of Queen Hatshepsut of Egypt, seems to have been triggered by a greater demand for spices, perhaps specifically for cloves and cinnamon for use in embalming. Both spices appear to have been valued from the earliest times for their medicinal properties.

Given the great distance covered by the Cinnamon Route, from the Spice Islands to east Africa, a long section of it without landfall, it seems likely that Madagascar was colonized when the route was first established. It would have provided a rest stop en route to Rhapta and a means for replenishing food supplies. The very considerable land area of Madagascar would have made it attractive to colonists. There is an obvious contrast here with the early settlement of Palau. There was neither land area nor richness in the coral atolls of Micronesia to explain their choice as possibly the earliest distant Spice Island colonies. Establishing settlements in Micronesia to give material support to long-distance voyaging to Japan makes practical sense.

In suggesting that the Spice Islanders established an early trading route to Japan perhaps 5,700 years ago and possibly founded a colony there in the same era, what we are proposing is a far greater antiquity for the maritime history, spice-trading history and colonizing history of the Spice Islanders than that which becomes obvious with their colonizing of the Bismarcks 2,000 years later. For many archaeologists the colonies in the Bismarcks correspond to the supposed first arrival of the Lapita peoples in Near Oceania. We suggest that the Spice Islanders, supported in the Ice

Age by the high SSTs of the WPWP, may have had at least trading contact with Near Oceania for tens of thousands of years before this and, as has been suggested, may have established an early colony in the Sepik River area of New Guinea, 6,000 years ago.

3.11 Maritime Expansions from a Maritime Ice Age Refuge

The close correlation of the maritime trading history of the Spice Islands with the oceanographic and volcanic history of the WPWP increases the likelihood that the ancestors of the colonizers of the Pacific are more likely to be found amongst peoples from a maritime Ice Age refuge, with a long maritime history played out within and on the borders of the WPWP, than amongst migrating rice farmers come lately from Taiwan. Indeed it would seem more likely for Spice Islanders to have colonized Taiwan, following the Kuro Shio Current north through the WPWP, than for Near Oceania to have been colonized from Taiwan against the flow of the ancient north-driving Kuro Shio Current.

A recent paper by Soares et al. [32], which uses complete mitochondrial DNA genome sequencing to trace the history of haplogroup E, suggests that the direction of gene flow was in fact from Island Southeast Asia to Taiwan rather than the other way around:

> Whatever the precise origin of haplogroup E may be, spatial frequency distribution and diversity strongly suggest that the haplogroup arose in ISEA and some of its subclades spread subsequently to Taiwan. Furthermore, we can infer a timescale for these processes using the coding region molecular clock. Early subclades are largely restricted to ISEA and date to the early Holocene. These are E1a1a1 (age 7,700 +/– 3,150 years), E1a2 (age 9,400 +/– 2,850 years), E1b (age 6,850 +/– 2,150 years) and E2b (age 66,700 +/– 1,800 years). This implies that the diversity of haplogroup E has been accumulating within ISEA for a minimum of 7,000–10,000 years.
>
> Applying a founder analysis to the subclades found in Taiwan, assuming ISEA as the source, yielded arrival time estimates of 6,550 +/– 1,850 years ago for E1a and 5,150 +/– 2,950 years for E2b. As these values were quite similar, we also applied a founder analysis to the entire haplogroup, combining data from both subclades, effectively assuming a single dispersal. The overall founder age for Taiwan came to 6,250 +/– 1,600 years. These results indicate that haplogroup E evolved in situ in ISEA and was involved in range expansions from ~ 12,000 years ago, reaching Taiwan roughly 4,000–8,000 years ago (pp. 1213–1215) [30].

The authors further note "a very close relationship between the geographical extent of post-LGM flake-blade industries and the haplogroup E lineages, again suggesting a close match between archaeological and genetic reconstructions" (p. 1216). In particular they comment that

> Zhang (2000) describes the appearance of a flake-blade industry, based on flakes struck from multiplatform cores, at 4 coastal sites in east Taiwan, all dated to 5,000–6,000 years ago. This would fit well with our estimated arrival from the south of E1a lineages in Taiwan (p. 1216).

The authors conclude

> Both the genetic and archaeological evidence therefore suggest that a maritime-oriented culture was in operation around the coastlines of what are now the Sulu and Sulawesi Seas by the LGM, which would have been pre-adapted to benefit from rising sea levels (Meacham 1984–1985; Oppenheimer 1998; Solheim 2006). The signature of dispersals from this region at the end of the Ice Age is evident both in the distribution of mtDNA haplogroup E lineages and the expansion of the flake-blade technocomplex (p. 1216).

We have suggested a post-glacial maritime expansion from the Spice Islands to Japan through the West Pacific Warm Pool. Interestingly, Soares and Trejaut et al. compare the genetic expansion of haplogroup E to post-glacial genetic expansions in Europe:

> The discovery of a signature of climate change in the human genome of Southeast Asians echoes similar findings for mtDNA haplogroups V and H in Europe. These haplogroups were carried from a glacial refuge in southwest Europe into western, central, and northern Europe following the retreat of the glaciers from ~ 15,000 years ago (Richards et al. 2000; Torroni, Bandelt, et al. 2001; Gamble et al. 2004; Pereira et al. 2005). Our results therefore reemphasize the critical role of climate change – in particular global warming after the LGM – in shaping the evolution of the modern human gene pool (p. 1216).

The later Spice Island maritime expansions to Hawaii, New Zealand and Madagascar might also be thought of as expansions from a maritime Ice Age refuge in response to the global warmth of the Holocene. But, as we shall see in Chapter 4, Spice Island maritime expansions had two additional motivations: finding a refuge following invasion and defeat and the need to establish rest and supply stations for long-distance trade routes with economic expansion rather than population expansion as a dominant motive.

3.12 Solheim and the Nusantao Trading Culture

The archaeologist Wilhelm Solheim [33] has described a present-day maritime trading network of Austronesian-speaking peoples operating along the western Pacific rim and into Island Southeast Asia: operating essentially along the edges of the WPWP (although Solheim has not conceived of it in these terms). Solheim traces the origins of this trading network back 7,000 years to post-flood Wallacea and the southern Philippines. He argues that

> Improvements in their sailing abilities was forced upon them by rising sea-levels. . .which required movement across gradually longer stretches of open sea to maintain contact with relatives and homeland. Outrigger canoes were probably necessary for the expansion of the Nusantao and the origin and center of innovation of all Austronesian boat traits probably lies in the islands surrounding Sulawesi.

The development of the early maritime skills and technologies that we have attributed to a long trading history for the Spice Islands, Solheim attributes to “the islands surrounding Sulawesi”. Given the close geographical affinity within Wallacea of Sulawesi and the Spice Island archipelago, early maritime innovations in the region, whatever their source, were likely to be shared. But though the Nusantao maritime culture that Solheim describes appears to have survived through 7,000 years to the present day, early Spice Island maritime history has a scope and range that sets it apart from Nusantao. We argue that it was the economic spur of spice trading that led Spice Island mariners from regional to international transoceanic trading and enabled them to become traders and colonizers in two oceans.

The persistent economic motivation of spice trading gives a coherence to Spice Island maritime history. It explains the Spice Islanders' transition from regional trading to long-distance coastal trading in the northern Indian Ocean and conceivably to early transoceanic trading across the width of the WPWP to Japan. More especially it explains their eventual development of transoceanic exploration and of trading that ranged as far as east Africa to the west and to America to the east. We suggest in succeeding chapters that the very scale and frequency of the transoceanic voyaging involved may imply that transoceanic voyaging was economically driven and that trading expansion was a persistent force in Spice Island maritime history.

In contrast, throughout its history, the Nusantao trading domain appears to have been regional, conducted along the western edges of the WPWP, supported by its high SSTs. The persistence to this day of the Nusantao trading culture, its connection to the WPWP and its use even today of double-outriggers to pursue maritime trade suggests the feasibility of the early maritime history we have sketched for the Spice Island ancestors of the Polynesians. But the contrast between Nusantao history and Spice Island maritime history emphasizes defining differences between them. Where the Nusantao trading network has remained regional, the economic spur of horticultural trading, arising from the possession of the valuable spices growing in the Spice Islands, and especially of the unique commodity of the clove, transformed Spice Island maritime history. It turned regional traders into international traders and regional voyagers into transoceanic voyagers who became explorers, traders and colonizers in two oceans. We have sketched only the beginning of that evolution in this chapter.

3.13 A Summary

In summary, Spice Island maritime history, as we envisage it, can be thought of as having three stages:

(i) local and regional trading in the Ice Age seasonally supported by the high SSTs of the WPWP;

(ii) regional obsidian trading in the mid-Holocene within the West Pacific Warm Pool (from Lou Island and Talisea to Sabah in Borneo), coastal spice trading in the northern Indian Ocean and, conceivably, transoceanic spice trading following the southern part of the Kuro Shio Current through Micronesia to Japan;

(iii) transoceanic trading to Africa and America, crossing the full width of the Indian and northern Pacific Oceans by following two of the four major currents flowing out of the WPWP to their continental limits, with early colonization of New Zealand achieved by following a third major ocean current flowing out of the WPWP into the southern Pacific Ocean.

We have only considered the earliest two stages of Spice Island maritime history in this chapter. We have suggested that archaeological evidence for early maritime trading in the Spice Island region, though scant, provides a context in which the early maritime history of the Spice Islands can be sensibly conjectured. And we have sketched the oceanographic and maritime background to the Spice Islanders' development of skills and technologies that, we argue, enabled them eventually to become international spice traders, voyaging, we have suggested, perhaps as early as 5,700 years ago to Japan in the north.

In the next three chapters our focus moves to the last and most remarkable stage of Spice Island maritime history. All three stages depend on and reflect changes in oceanographic conditions in the WPWP and the three stages we have defined form a logical progression. At every stage oceanographic conditions within the WPWP determined the maritime possibilities open to Spice Island mariners. And at every stage it was the Spice Islanders' innovative response to these conditions, given the persistent impetus and economic motivation of spice trading, that determined maritime and trading outcomes.

For perhaps 2,000 years within the WPWP long-distance voyaging nursery, in what we envisage as the second stage in their maritime history, Spice Islanders perfected the skills and technologies they had developed in response to the strong currents and to the exceptionally high SSTs that appeared in the WPWP after the last Ice Age flood. Their innovative adoption of a sailing strategy of following fast currents over long distances and their development of the double-outrigger able to exploit fast currents safely led them eventually to expand their mastery of transoceanic (as opposed to coastal) voyaging into colder ocean waters outside the WPWP. This expansion marked their moving to what we describe as the third stage of their maritime history.

The third stage of Spice Island maritime history, we suggest, was made possible by mariners, during global warm periods, following at least three of the four major fast warm currents flowing out of the WPWP, exploiting the power and warmth of these currents to provide some protection against hypothermia. We shall show how, using their awareness of the predictable behaviour of ocean currents in response to nearby landmasses (due to the Coriolis effect), Spice Island explorers were able to rapidly discover and settle the largest uninhabited islands in two oceans. In this third stage, Spice Island mariners, over time and in a logical sequence, during global warm periods, effected remarkable maritime, trading and demographic expansions in two oceans. Documenting these expansions is our focus in the next three chapters.

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Chapter 4
Transoceanic Trade and Migration (1)

Following Currents from the West Pacific Warm Pool into the Indian Ocean: The Cinnamon Route and the Colonization of Madagascar

Abstract For probably 500 years before the descent of a global cold period in about 1000 BC and for a thousand years after it ended, there is evidence that mariners followed a major West Pacific Warm Pool current from the Spice Islands to east Africa over a distance of more than 11,000 km. This trade route became known as the Cinnamon Route. Evidence from many sources supports the historicity, range, consistent use and economic viability of the Cinnamon Route: historical evidence stretching back to Roman times for its existence as a trade route; maritime evidence from the survival to the present day in the Indian Ocean of the Halmaherian double-outrigger that sailed the route; and genetic evidence of Spice Island involvement with the route as early colonizers of Madagascar based on the possession by Malagasy of Asian descent of a near-coalescent Polynesian motif.

Keywords Cinnamon route · Madagascar · Double-outrigger · Polynesian motif · Terqa

4.1 Introduction

A prehistory for the Lapita peoples in which, whether in the short-term or over a longer period, they are seen as in transit in Island Southeast Asia suggests they were a single cohesive group. It suggests a single migration which moved through Island Southeast Asia into Remote Oceania and then out into the Pacific. This scenario does not encourage us to think about Spice Island populations which remained in Island Southeast Asia and provided a base for future migrations from the region.

If, however, the Lapita people are seen as an ancient people indigenous to the Spice Islands, the continuing history of genetically, culturally and linguistically related tribal peoples, who remained in the region after the Lapita exodus, needs to be explored.

We have suggested the possibility of a long migration history for the Spice Islanders within Island Southeast Asia, perhaps dating back to the drowning of Sundaland in the Ice Age floods of 11,500 and 7,500 years ago. The speed and

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success of the Lapita migrations into Remote Oceania may imply significant previous migration experience. But it seems unlikely that, even in a time of natural disaster or of invasion, all peoples from the thousand islands of the Spice Island archipelago and related peoples from any colonies they may have established in Island Southeast Asia would have abandoned their homelands at the same time. Instead of thinking about the Lapita peoples as a single people in transit, perhaps we can more usefully think in terms of a widespread tribal maritime culture of great antiquity indigenous to the Spice Island region. This tribal maritime culture might be thought of as comprising genetically related, Austronesian-speaking tribes, most of them by 3,500 years ago of very considerable antiquity, independently adapting and responding to crises, conflicts and opportunities and probably competing with one another.

A simplistic migration history is suggested by the paradigm of a single people in transit from Taiwan to Near Oceania. A more complicated ancient and continuing migration history is possible with the time depth we claim for the Spice Islanders. The period spanned by Spice Island migrations for which we have evidence is in fact considerable. Migrations from the Spice Islands appear to have begun as early as 5,700 years ago (the earliest date suggested for the colonization of Ngerekebesang Island in Palau in western Micronesia) [1] and to have extended at least to Rakaihautu's migration to New Zealand (in about AD 840 by our calculation), a span of 4,500 years.

It is important, however, to remember that global climatic conditions constrained long-distance voyaging. Thus the first settlement of Madagascar can only have occurred before 1000 BC or after 400 BC. If Madagascar was colonized before 1000 BC (a "first-wave" settlement), the descendants of the first colonists or traders would have been isolated for perhaps 600 years till warmer sea surface temperatures made it possible for mariners to sail the Cinnamon Route again and for new colonists to arrive in Madagascar (in a "second-wave" migration).

The same climate constraints would have applied to all other long-distance migrations from the region. The first settlement of Hawaii and New Zealand and the initial colonization of Japan also can only have occurred before 1000 BC or after 400 BC, and in Hawaii and New Zealand, as for Madagascar, colonists would have been isolated for 600 years.

It is also important to make the point that Spice Island migration history, in the last 2,000 years, involving Madagascar, New Zealand and Hawaii, needs to be read not just as part of a local or regional history. It needs to be read in the wider context of international history. Warmer global conditions 2,000 years ago favoured the expansion and increasing wealth of the Roman Empire, fuelling an unprecedented demand in the empire for spices. Warmer conditions also favoured maritime trading in the Indian Ocean. In AD 76, according to Abraham Fornander, working from the Malay Annals, Island Southeast Asia was invaded by Arab, Indian, Chinese and Malay traders aggressively seeking a share of the lucrative spice trade [2]. Foreign traders set up trading stations to challenge the indigenous spice monopoly and may indeed have encouraged local rival tribes to attack the Spice Islanders as a way of destabilizing local trading networks.

Between the time of the foreign traders' arrival in about AD 76 and AD 196, when the Emperor Han of China opened the Silk Road, there seems to have been a concerted effort by foreign traders to break the indigenous spice trade monopoly. The opening of the Silk Road was a matter of providing guards to deter brigands along what was already an ancient trade route. Once opened, the Silk Road was used to supply China by land with Indian spices and with Moluccan and Indonesian spices traded through India. The opening of the Silk Road may have represented a challenge not only to an indigenous maritime spice monopoly but also to maritime control of the spice trade. It may have been seen by Chinese and Indian traders as a way of generating wealth by trading spices onwards to Europe by a now safer land route which bypassed the maritime control and involvement of Spice Island, Wallacean and East Indonesian mariners and also of the competing Arab Indian and Malay traders who had moved into the region over a hundred years earlier.

The setting up of Malay, Chinese, Indian and Arab trading stations in Island Southeast Asia in the 1st century AD not only corresponded to a major increase in the demand for spices from the Roman Empire, but also reflected the determination of foreign traders to gain a major share of the wealth that could be gained from meeting that demand. According to traditional histories it would appear that a concerted attack on indigenous spice traders followed. It is possible that by promoting inter-tribal conflict foreign traders sought to gain effective control over spice sources. Polynesian traditional histories paint a picture of attacks by lanky, black-skinned tribes. Defeated tribes, these traditions make clear, had no option but to migrate or face extinction. Traditional histories show that defeated tribes, who we are told used navigational directions handed down from early ancestors (first-wave explorers), successfully migrated to both Hawaii and New Zealand.

4.2 The Maori *Whare Wananga* Traditions

In New Zealand, oral history was passed down through *whare wananga* or schools of learning. Traditions passed down through one of these schools and recorded in the early 20th century by S. Percy Smith reveal factors triggering early migrations within and from the Polynesian homeland in this period. These oral accounts can be matched to the historical context of conflict and destabilization in the Spice Islands that we have outlined.

In Chapter 16 we study oral traditions that tell of Maui the Navigator's visit to New Zealand and of the earlier humiliating defeat suffered by his father. Our analysis of these traditions suggests the possibility that the defeat of Maui's father may well have followed from a direct or fostered challenge to Spice Island or Wallacean spice traders by foreign interests. The chronology we ascribe to Maui's visit to New Zealand in about AD 100 (see Chapters 16 and 19) and to the defeat of his father, possibly a generation earlier, matches Fornander's estimate of AD 76 for the invasion of the Spice Island region by foreign traders. Maui's exploratory visit to

New Zealand and Hawaii, we suggest, may have been to search for possible refuges for his people in the case of their eventual defeat.

The pattern of defeat and enforced migration, perhaps anticipated by Maui, is described in the Maori whare wananga traditions [3]. These traditions, for example, tell of the early explorer, Tama-rereti who discovered Hawaii and led his own family (sub-tribe) in a migration there. That the constellation of Scorpio was named in his honour (*Te Waka-o-Tama-rereti* or the canoe of Tama-rereti) suggests the antiquity of these events and the likelihood that Tama-rereti's discovery of Hawaii belongs to the first wave of exploration which ended in about 1000 BC. Perhaps 30 generations later, in a time of strife and defeat, Tama-rereti's sailing directions for reaching Hawaii were remembered by his tribe now threatened with extinction. The defeated tribe followed Tama-rereti's instructions and reached Hawaii. Perhaps 400 years after this, Irapanga, perhaps following the sailing instructions of his ancestor, Maui the Navigator, is said to have led a colonizing fleet of six canoes which sailed north from the Spice Islands through Micronesia towards Japan and then followed the Kuro Shio Current that flowed beyond Japan east towards Hawaii. Tradition tells us that Irapanga's people landed and settled on the Hawaiian island of Oahu.

The whare wananga traditions record two ancient colonizations which probably took place within Island Southeast Asia: from an ancient homeland, Irihia, to Tawhiti-roa (possibly Sumatra) and then from Tawhiti-roa to Tawhiti-nui (possibly Borneo). These migrations were led by four chiefs in a fleet of seven canoes, following invasion and defeat by what are described as thin, lanky, black-skinned men. The account draws attention to the vulnerability of new migrants in an already settled land. It describes the first task for such migrants to be the building of a *pa*, a fort, for protection against attacks from the local inhabitants. In the whare wananga account, following their arrival in Tawhiti-nui there was discussion by the four chiefs as to what kind of pa to build:

> Tawhito-rangi considered they should build a stone fort, whilst Tu-rongo-rau thought a wooden [i.e. palisaded] one best, with three lines of defence. Tu-te-mahurangi and Mahurangi said that the best pa for them would be to ascend to the midst of a cliff and there excavate a deep place, so that when they went forth to seek food for themselves, the pa of the women and children could not be taken by any people who might come to assault it [4].

This account suggests how old the tradition of pa-building was and how vital pa-building was for migrants arriving in low numbers and settling in an already peopled land. The attractiveness of migration to a distant uninhabited land or sparsely inhabited land is obvious, despite the inherent risks of long-distance voyaging.

In both the whare wananga traditions and the oral traditions preserved in New Zealand of Maui's visit, invaders are described as lanky and black-skinned. The description implies the Polynesians' awareness of their own robust cold-adapted body form and of their paler skin. It makes clear too that the invading tribes were not cold-adapted and so would not have been able to trade the spices themselves over long ocean distances. In the early centuries AD they presumably became suppliers to foreign maritime traders.

It is interesting that the New Zealand traditions of Tama-rereti's migration to Hawaii are matched in Hawaii by similar accounts of the early discovery and settlement of Hawaii by Hawaii-loa, after whom it is said Hawaii was named. Whether the same man appears under two names or whether there were indeed two early separate founding settlements is unclear.

The pattern of enforced migration for a people defeated by invaders may be very ancient, possibly predating the first wave of exploration and colonization in the Pacific. Developing the sailing strategy of following fast warm currents flowing out of the West Pacific Warm Pool would have given Spice Island tribes, in the event of defeat, the option of migrating beyond the region and so beyond the reach of their enemies

A second motivation for oceanic migration appears in traditional histories: determination on the part of the explorer's family or descendants to claim land rights by virtue of relationship to or descent from the discoverer.

A third motivation for the founding of a distant colony was an economic one: the establishment of a supply base for a trading route or establishing a trading station at the terminus of a route. Given the absence of traditional histories in Madagascar, it is unclear whether defeated Spice Island tribes chose Madagascar as a refuge. What is obvious is that Madagascar was needed as a rest and supply station for the Cinnamon Route. Given its land area, multiple, differently motivated migrations to Madagascar are conceivable. Prehistorians tend to think in terms of a singular founding migration. Traditional histories record multiple migrations to a given destination over time, both by tribes, descended from the discoverer, who inherited his sailing instructions and used them to take up land rights by virtue of descent or by tribal descendants remembering ancient sailing instructions when faced with defeat.

4.3 The Cinnamon Route

By virtue of its geography, the colonization of Madagascar clearly stands outside the simplistic Lapita paradigm in which the settlement of the Pacific is seen as following directly and sequentially from the Lapita colonizations of Near Oceania, Island Melanesia and Western Polynesia. Instead, the colonization of Madagascar fits the more complicated migration paradigm we have suggested of a long and continuing migration history for descendants of indigenous Spice Islanders.

The dating of the first settlement of Madagascar is, however, far from easy to determine. It almost certainly followed from – indeed arguably would have been necessary for – the establishment of the Cinnamon Route. Madagascar would have been a vital rest stop en route to Rhapta which lay about 2,000 km beyond Madagascar.

We have suggested that the Spice Islanders' skills in handling fast currents, and possibly their development of the double-outrigger able to exploit these currents, evolved in the Kuro Shio voyaging nursery some time between 7,000 and 5,000 years ago. Archaeological evidence for an extension of voyaging range and for

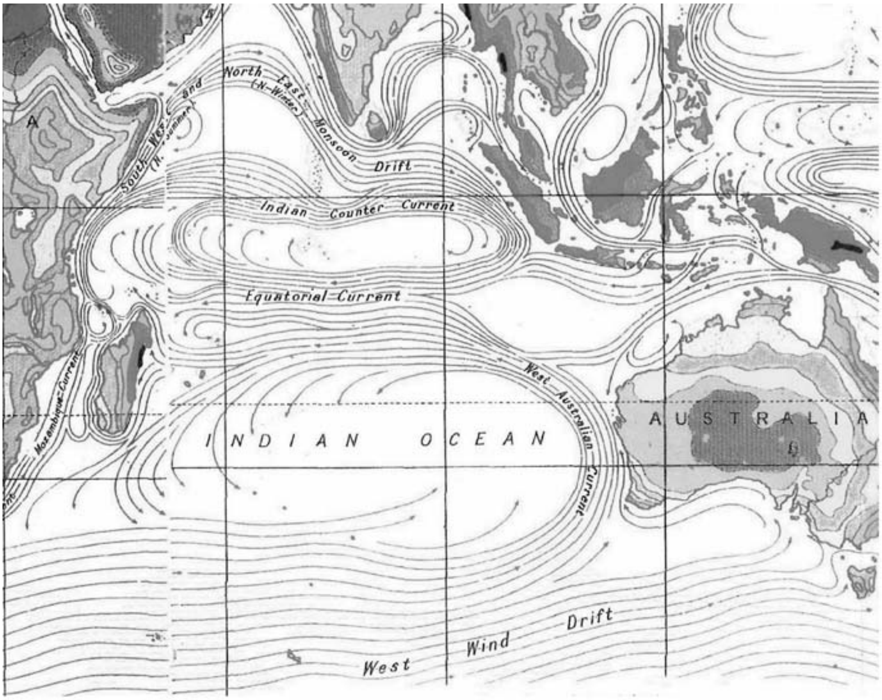

Fig. 4.1 A map showing the clockwise ocean loop made by the Equatorial Current and the Indian Counter Current used in sailing the Cinnamon Route (based on a map of world ocean currents on pp. 12–13 of *The Time Concise Atlas*, Australian edition, 1976. Copyright Times Newspapers Ltd & John Bartholomew and Son). Reproduced with permission from HarperCollins Publishers

international maritime trading 6,000 years ago by a coastal route to the Middle East suggests an advance by this date in the Spice Islanders' maritime skills and cold resistance. The Egyptian demand for cloves and cinnamon for use in embalming may date back to the practice of mummification 5,000 years ago. But it is unlikely that the Cinnamon Route was established as early as this. Sailing the Cinnamon Route involved sailing a vast open ocean distance exploiting monsoonal winds and strong currents. Probably the challenge of transposing skills from the protective warmth of the West Pacific Warm Pool to a colder ocean delayed its establishment. Instead of voyaging with many possible rest stops, as in Micronesia, the Cinnamon Route meant meeting the challenge in the Indian Ocean of a long direct ocean crossing with few possible landfalls. As long as spices could be adequately supplied to Egypt by the long northern coastal route, these challenges would probably have been postponed. That there was a specific later trigger for establishing the Cinnamon Route seems likely. What this trigger may have been can only be surmised. We do know that historians associate the reign of Queen Hatshepsut (1503–1482 BC) with a sudden increase in the Egyptian demand for spices. It is not unreasonable to suggest that this increased demand for spices, and especially for cloves and cinnamon, may have been the trigger for the establishment of a direct route from the Spice Islands to Rhapta. If so, it would probably also have been the trigger for the initial colonization of Madagascar.

Prehistorians, however, are divided on the timing for this migration. Victor King [5], noting that the Madagascan languages "are most closely related to the south-east Barito language family including Ma'anyan (Dyen 1971)" of Borneo, comments, for example,

> It has been suggested that Austronesians from southern Borneo may well have settled in east Africa relatively recently, from the mid- or late-first millenium (see Bellwood 1978: 124) and may have been members of boat-crews organized under Malay or Javanese control (Adelaar 1990: 7). But Glover draws attention to regular trading contacts across the Indian ocean even during the first millenium BC.

Matthew Hurles et al. [6], quoting Dahl [7] and Adelaar [8] more specifically claim that the Austronesian Malagasy language of Madagascar "shares 90% of its basic vocabulary with Maanyan". Following Dewar and Wright [9] and Burney et al. [10], Hurles et al. believe that Madagascar was settled 1,500–2,000 years ago from the Barito River area of Borneo.

On the other hand, J. Innes Miller [11] believes that a "study of the Sanskrit element in Malagasy as compared with that in Malay is important as an indicator of when the colonization of Madagascar occurred". He argues that the Sanskrit terms used in Malagasy refer to "common objects affecting everyday life" and that these "were probably brought in by Kalingan traders long before hinduization by settlement began". He contrasts such vocabulary with "that dominant in and around the Courts" and associated with Hindu migrations into Island Southeast Asia dating to the beginning of the Christian era. He explains

> Kalinga was one of the historic kingdoms of India. . .famous for its maritime trade. . .It was conquered by Asoka in 255 B.C. Sanskrit had been in use in India since about 1500 B.C., and the vigorous and homely Prakrit derivatives dealing with trade, agriculture, and domestic life, which are common to the Malay and Malagasy languages, could only have come when Kalinga was a strong and active power. The beginnings of the Indonesian or Malagasy settlement of Madagascar may therefore go back to the second millenium B.C., to the time of the Shang or Yin dynasty in China and that of Hatshepsut in ancient Egypt, and it was along the route which ran direct from Java to Madagascar, and thence via Rhapta to the Nile Valley and the Somali ports, that the cassia and cinnamon of China and south-east Asia came to the Mediterranean in Roman imperial times. This was the Cinnamon Route (p. 166).

Suggested dates for the colonization of Madagascar thus stretch over 2,400 years from 1500 BC to AD 900.

We know, from the cloves found in Terqa and dated to 1721 BC, that the international trade in spices grown in the Spice Islands is close to 4,000 years old at least. Given this fact it is not unreasonable to suppose that the Cinnamon Route may have been established 3,500 years ago as Miller suggests: possibly set up specifically to supply the embalming spices, cinnamon and cloves, to Egypt. It is clear that only cold-adapted, famine-resistant mariners could have sailed the route from the Spice

Islands to Rhapta, either on sailing rafts or in double-outriggers, and that they could only have done so in warm climate periods. According to Pliny the Elder, the width of the Indian Ocean was crossed in high winds in winter (presumably exploiting the winter monsoon). The route included a long stretch without landfall on a journey of about 11,000 km.

4.4 The Origins of the Malagasy

Linguistic evidence, however, appears to establish the Barito River area of Borneo, not the Spice Islands, as the home of the Madagascan colonists, and Y-chromosomal evidence appears to support this view. Hurles et al., studying the paternal lines of the Malagasy and of people from the Barito River area, note that the "genetic proximity between the Malagasy and Borneo populations reflects the presence of appreciable frequencies of lineages O1b and O2a* in both populations, as well as a relative lack of chromosomes belonging to O3 lineages" [12]. They point out that "the predominant Y-chromosomal haplogroups found in Polynesians, O3 and C, are not found at all among Malagasy paternal lineages" (p. 899).

However, although both linguistic and Y-chromosomal evidence suggest an origin for Madagascan colonists in Borneo, this is contradicted by evidence from maternal lines. Soodyall, Jenkins and Stoneking make the point that while the Polynesian motif, which has been sourced by Oppenheimer to the Spice Islands and Wallacea on the grounds of genetic diversity [13], "occurs in some parts of Borneo and East Indonesia at low frequencies. . .it is not found in Indonesians from the Barito River area (Borneo). . ., showing a lack of concordance between the linguistic and the genetic data concerning the origins of the Malagasy" [14]. They comment that the presence of the Polynesian motif in Madagascar "suggests that the founders of Madagascar were Polynesians or Polynesian ancestors" and that their study shows "that migrations out of Southeast Asia led to the colonization not only of Oceanic Islands, to the east, but also to Madagascar to the west".

The apparent contradiction between the maternal and paternal evidence for the origins of the Malagasy may have a simple explanation. Soodyall, Jenkins and Stoneking suggest that the ancestors of Polynesians could have been founders in Madagascar. They note that the "The frequency of the Polynesian motif is 18.2% in the Malagasy; this was found at 96.2% of individuals with the 9-bp deletion" derived from an Asian as opposed to an African source [15]. The near-complete coalescence of the Polynesian motif in modern Malagasy populations of Asian descent suggests a significant time span since a (probably first-wave) founding migration reached Madagascar. It is likely that the Malagasy Y-chromosome lineages represent a later, probably second-wave migration. For what the absence of O3 and C Polynesian lineages among Malagasy paternal lineages suggests is a second-wave attack on a first-wave colony in which men were slaughtered by the invaders and women spared. Founding paternal lineages would have been wiped out, founding maternal lineages preserved.

This is a realistic scenario given that Austronesian societies were matrilineal and matrilocal. That is, land ownership was through female lines of descent. Invaders would have spared women in order to secure land rights through them as well as to build sustainable population levels quickly. This scenario suggests initial colonization by Spice Islanders, bringing the Polynesian motif, to Madagascar. There may have been several second-wave colonizations (perhaps more than one by second-wave Spice Island traders) before, as the genetic picture suggests, there occurred a final attack or attacks by men whose Y chromosomes link them to the Barito River area of Borneo. These later invaders, by slaughtering the men on the island, could have wiped out the Y-chromosome genes of the Spice Island founders and of any later Spice Island colonists and imposed their language on the Malagasy. Attacks of this kind are repeatedly recorded in traditional histories. They drove the choice between tribal extinction and oceanic migration that led to colonizations in Hawaii and possibly in New Zealand.

Genetically cold-resistant women in Madagascar over time could have passed their genes for cold resistance to the Barito invaders or the invaders could have acquired them through earlier invasions of spice-producing islands in the Spice Island archipelago with the same sparing of cold-adapted women and slaughter of defeated men. Invaders from Borneo would have to have had significant cold resistance for, as we have noted, only cold-adapted mariners could have sailed the Cinnamon Route.

4.5 Dating the First Settlement of Madagascar

We know that Madagascar, by the time of the Roman writer, Pliny the Elder (AD 23–79), was a major staging post for the Cinnamon Route. Double-outriggers from the Spice Islands carried cargoes of spices via Madagascar to Rhapta: cinnamon from the islands of Seram and Ambon in the southern Spice Islands where it was indigenous (though it also grew in Java), cloves from the Halmaherian off-shore islands and nutmeg and other spices from Banda also in the southern Spice Islands.

In his *Historia Naturalis*, Pliny the Elder, who had studied Greek sources and was in touch with the mercantile community in Rome [16], described the feat of bringing spices to Madagascar and to the ports of the east African coast by the Cinnamon Route. Pliny's marvellous, if inaccurate, description of the double-outriggers or sailing rafts that carried the spices to Rhapta reads as a paean of praise to the courage and daring of the mariners who sailed them:

> They bring it [the cargo] over vast seas on rafts which have no rudders to steer them or oars to push or pull them or sails or other aids to navigation; but instead only the spirit of man and human courage. What is more, they put out to sea in winter, around the time of the winter solstice, when the east winds are blowing their hardest. These winds drive them on a straight course, and from gulf to gulf. Now cinnamon is the chief object of their journey, and they say that these merchant-sailors take almost five years before they return, and that many perish. In exchange, they carry back with them glassware and bronze ware, clothing, brooches, armlets, and necklaces (p. 171).

In the Holocene sailing rafts almost certainly had daggerboards and/or a steering oar and a sail to exploit a following wind or, in the case of the Cinnamon Route, to exploit monsoonal winds driving westwards across the Indian Ocean. The bas-relief depiction of a sailing raft from the 8th century temple of Borobudur in Java shows a daggerboard, a steering oar and sail. Given the conservatism of ship design, this depiction probably shows sailing rafts as they had been for thousands of years. There are also five bas-reliefs at Borobudur of what A.C. Haddon and James Hornell [17] describe as “Halmaherian” double-masted double-outriggers. This name sources the double-outrigger directly to Halmahera and the Spice Islands, the starting point for the Cinnamon Route. Halmaherian double-outriggers may have sailed the Cinnamon Route alongside sailing rafts.

Though the single-outrigger became dominant in the Pacific, the double-outrigger survived in Indonesia down to the 21st century. In early 2006, for example, Papuan refugees from Irian Jaya fled in a double-outrigger to Australia, their version of this ancient vessel powered by an outboard motor. In 1927 Hornell found double-outriggers still in Madagascar though they were then being replaced by single-outriggers.

If the Cinnamon Route was established 3,500 years ago, the first settlement of Madagascar would almost certainly have occurred then. At the very least a trading station would have been set up in Madagascar at this time to provide a rest and supply station for mariners, given the long stretch of ocean that had to be crossed with few landfalls to reach Madagascar.

According to an Alexandrian merchant, Cosmas Indicopleustes, the Cinnamon Route was still being used in the 6th century AD [18]. If the route was established

Fig. 4.2 A bas-relief depiction of a Halmaherian double-masted double-outrigger from the 8th century temple of Borobudur in Java (photo courtesy of P. Beale/The Borobudur Expedition)

in the reign of Queen Hatshepsut, this means that the Cinnamon Route had a life of 2,000 years (interrupted by the 600-year cold period after 1000 BC).

As noted earlier, if Madagascar was colonized before 1000 BC (a first-wave settlement) the descendants of the first colonists or traders would have been isolated for 600 years till warmer sea surface temperatures made it possible for mariners to sail the Cinnamon Route again or for new colonists to arrive in Madagascar.

We have seen that the dates for the first settlement of Madagascar suggested by prehistorians stretch over 2,400 years from 1500 BC to perhaps as late as AD 900. In contrast, with the lack of consensus amongst prehistorians, there is some sharp indirect dating evidence for the first settlement of Madagascar recently provided by Burney et al. [19]:

> Many lines of evidence converge on the notion that humans first settled in Madagascar about two millennia ago: 1) first occurrence of human-modified bones of extinct animals, 2) first occurrence of pollen of introduced Cannabis/Humulus (probably the former, see Merlin, 2003), 3) sudden large increases in microscopic charcoal particles above background values, and 4) an increase in ruderal pollen and other vegetational disturbance indicators. These key events have all been dated to within three centuries of 2000 14/C yr BP. Studies of the Malagasy language also show a separation from its closest surviving linguistic relatives in the highlands of Borneo about two millennia ago (Dahl, 1951). Divergence could have begun before proto-Malagasy speakers departed from Indonesia, of course. If people had arrived many centuries earlier, they would have predated the advent of the Iron Age. No plausible evidence has been found for a stone-age culture on Madagascar (Dewar, 1984). This is merely a negative-evidence argument, but the persistence of stone artifacts in the archaeological record is much better than iron, yet no stone tools except sinkers and musket-flints have been found.
>
> The very earliest date for a human presence, 2325 ± 43 yr BP (2366–2315 cal yr BP), comes from the SW interior site of Taolambiby. It is from a radius of the sloth lemur *Palaeopropithecus ingens* with cut marks that suggest flesh removal with a sharp object (Perez et al., 2003). This is approximately coeval with the earliest occurrence of Cannabis/Humulus pollen at Tritrivakely in the central highlands, at an interpolated age of 2200 cal yr BP (Burney, 1987a; Gasse and Van Campo, 1998). A human-modified femur of extinct Hippopotamus from Ambolisatra on the SW coast yielded an age of 1970 ± 90 yr BP (60 BC–130 cal yr AD) (McPhee and Burney, 1991). Thus, a conservative estimate for the earliest human presence on Madagascar is ca. 2300 cal yr BP (350 cal yr BC).

This indirect evidence, however, needs to be considered in the context of global climate history. For, as we have seen, warm climate periods and associated high SSTs determined both the periods in which it was feasible for mariners to sail the Cinnamon Route and the periods in which it was feasible for migrants to sail to and settle in Madagascar.

It would have been possible for cold-resistant mariners to have sailed the Cinnamon Route in the significantly warm period from 3,600 to 3,000 years ago (the Lapita period) and, as we have seen, the new demand for spices, especially for mummification, in the reign of Queen Hatshepsut of Egypt (1503–1482 BC) may have provided motivation for establishing the route. The warm conditions in this period would also have favoured mariners establishing a trading station or colony in Madagascar.

However, low SSTs in the long cold period that followed in about 1000 BC, and in the southern hemisphere lasted till about 400 BC, would have made it impossible for the Cinnamon Route to be maintained in this period and unlikely that a colony could have been established in Madagascar then.

It is interesting that the date for first indirect evidence of a human presence in Madagascar (2,366–2,315 cal yr BP) coincides with the end of this severe global cold period in the southern hemisphere. But before we consider this as evidence that Madagascar was first colonized then, we need to consider the question of how long it takes for a founding population to have a recognizable impact on an environment. David Burney and Tim Flannery [20] comment that

> Founding human populations, especially those that find themselves on larger landmasses (or perhaps grow slowly owing to disease or other factors) thus might be impossible to detect with the use of customary archaeological techniques, such as surface survey and excavation of artefacts. . .The low number of founding humans might take a few centuries to fill up the new landscape with archaeological evidence that can rarely, if ever, be subsequently detected before some critical level of human density is achieved.

Madagascar would certainly count as a "larger landmass". If the Cinnamon Route was established during the reign of Queen Hatshepsut and a trading station or small colony set up in Madagascar, its population level at the end of the severe global cold period may only by then have reached a level where its impact on the environment was detectable. For a small population may not have thrived in isolation. As we shall show in Chapter 20, tradition implies a near-extinction event in New Zealand when a small population was isolated in the same cold period.

The indirect evidence of Burney et al. suggests there was a population in Madagascar already impacting on its environment by 400–300 BC; it is possible that an earlier population established before the cold period was responsible for the archaeological evidence that has been found.

Burney et al. comment

> It is worrisome that there are no dated occupation sites during the first half millennium of significant indirect evidence for a human presence – including bones cut in an apparently fresh state; introduced pollen, disturbance indicators, and particulate charcoal in cores; and Sporomiella decline [21].

Perhaps the absence of settlement sites at this date suggests the population, either of just arrived colonists or of a depleted remnant from an earlier colonization, or of both combined, must have been relatively small. There is a gap of 900–2,300 years on the island of Ngerekebesang in western Micronesia from first palaeo-environmental evidence of settlement to the earliest archaeological evidence yet discovered [22]. Such a gap reinforces Burney and Flannery's point about the times taken for small populations to leave an archaeological footprint. It seems not unlikely that the evidence of ecological disturbance dated to a time immediately after the end of the global cold period could indicate that both a new colony and an earlier population were involved. H.H. Lamb [23] notes that it is a common human experience for migrants to a new land, which they thought uninhabited, to find settlers who had arrived there in a former warm period.

We are left with the possibility of an early establishment of the Cinnamon Route and an early first-wave discovery and colonization or colonizations of Madagascar in the Lapita period or a later second-wave establishment of the Cinnamon Route and a later associated settlement or settlements of Madagascar after 360 BC or the more likely possibility that both may have occurred. That the initial settlement was by Spice Islanders seems certain and that it was early seems likely, given the 96.2% incidence of the Polynesian motif amongst individuals carrying the Asian as opposed to the African 9-bp deletion. The total replacement of Spice Island ancestral Y chromosome haplogroups by those from the Barito River area of Borneo, as we have commented, suggests later invasion. Indeed, there may have been a sequence of second-wave invasions, with the last male invaders violently removing all Y chromosomal evidence not only of the earliest Spice Island settlers but of all subsequent colonists and invaders.

The place that the Cinnamon Route and the colonization of Madagascar hold in the likely sequence of events in Spice Island maritime history supports the likelihood that Madagascar was first settled before 1000 BC. There is archaeological evidence that Spice Island explorers reached southern California before 1000 BC (see Chapter 6). The distance from the Spice Islands to southern California is roughly the same as that from the Spice Islands to Rhapta. But it seems likely that spice trading would have given an impetus to the prior establishment of the Cinnamon Route. Given that a rest stop at Madagascar was vital to the safe and practical sailing of the route, a colonization of Madagascar before 1000 BC seems likely.

Further colonizations of Madagascar in response to destabilizations of the spice trade in the Spice Islands and Island Southeast Asia are also conceivable. This is especially so after AD 76 when the concerted efforts of foreign traders to take control of the indigenous maritime spice trade may well have prompted migrations to Madagascar, for tradition tells us that conflicts in this period led to later migrations from the Spice Islands to two other distant migration targets, New Zealand and Hawaii. The significant size and probable low population of Madagascar would have made it attractive to migrants. The fact that there are four ethnic populations in Madagascar (Bezanozano, Betsillo, Merina and Sikanaka) may imply a history of multiple migrations comparable to those which tradition records for New Zealand and Hawaii.

Since no stone tools have been found on Madagascar, it seems likely that evidence of an earlier Neolithic Spice Island colony has been lost and that the Iron Age technology of second-wave colonists and possibly their Barito-based language overlaid the culture and language of the descendants of first-wave Neolithic colonists. It is curious that most of the earliest indirect evidence appears to come from sites in the interior. One would expect the earliest settlement sites for spice-trading mariners to be coastal, located at the best harbours. That this is not the case perhaps supports the likelihood that evidence for the earliest first-wave Neolithic coastal settlements has either been buried or lost through erosion or tsunami inundation or is yet to be found.

Whatever the date for the first settlement of Madagascar may prove to be, it is clear that only cold-adapted, famine-resistant mariners could have sailed the

Cinnamon Route on sailing rafts or in double-outriggers to settle Madagascar. The likelihood that they were Spice Islanders or genetically related to Spice Islanders is therefore high. Miller's suggestion, that the indigenous people sailing the Cinnamon Route may eventually have lost their role as independent traders and come under Malay or Javanese control, seems plausible. That the island of Ambon in the southern Spice Islands may have been home to at least one group of colonists is suggested by the fact that this is the one Spice Island place name that seems to have survived in Madagascar.

The question of when the Cinnamon Route was established and when Madagascar was first and subsequently settled perhaps should be considered in an historical context that takes account of surges in the international demand for spices and associated destabilizations in the spice trade. The speed with which the Indian Ocean could be crossed by double-masted double-outriggers driven by strong monsoonal winds and powerful currents would have given indigenous traders a time advantage over their foreign rivals in getting spices via Rhapta to Egypt and Europe. Surely it must have been just such an advantage that led to the initiation and regular use of the Cinnamon Route.

With spices so keenly sought in Rome, competition and conflict amongst international traders and perhaps even amongst indigenous traders was inevitable. Indeed, competing attempts to take control of the supply sources for spices was to shape the history of Island Southeast Asia for the next 1,600 years. The history of invasion and slaughter of males on Madagascar, possibly implied by the genetic evidence, suggests that there was little hope for indigenous spice traders to maintain lasting control of spice sources or even of some of the spice trading. The spice trade outlasted the Roman Empire. Once established in Europe, the demand for spices continued unabated. Repeated foreign invasions and exploitation of the Spice Islands and the Spice Islanders in the end involved major European powers and lasted down to the end of the 18th century.

In an era when spices can be bought cheaply in Western supermarkets, the enormous importance and lucrativeness of the ancient spice trade can hardly be grasped. It is far from extravagant to claim, as many historians have done, that the spice trade shaped world history for millennia, prompted the Spanish to cross the Pacific from America, motivated the long-distance European oceanic explorations of Columbus and Magellan, triggered competing European explorations and colonizations and played an early part in the development of the competitive European global empire-building that led to the Boer War and World War I. Its impact on the history of Island Southeast Asia was fundamental. The opening up of the archipelago over 1,600 years to foreign, local, European and Asian cultures and religions, by traders seeking competitively to dominate and control the spice trade and by the missionaries who followed the traders, led to the overlaying of indigenous cultures and religions, often with brutal exploitation of indigenous peoples. For indigenous Island Southeast Asian peoples this has led effectively to an almost total loss of knowledge of their early history. As far as we know, there are no traditional histories or genealogies preserved in Madagascar or in the Spice Islands that can open windows on their long migration histories.

4.6 A Replica Voyage from Java to Africa

In 2003, a navy-trained, London fund manager, Philip Beale, left his job to fulfil his dream of creating a replica of the Borobudur ship, the Halmaherian double-outrigger shown in bas-relief carvings on the walls of the 8th century temple of Borobudur in Java. Haddon and Hornell tell us that five of the eight ships pictured at Borobudur are double-masted double-outriggers and claim that the bas-reliefs at Borobudur are the oldest archaeological evidence for such ships from the Indonesian area [24].

There is no doubt that Halmaherian double-outriggers sailed the Cinnamon Route, possibly as long as 3,500 years ago, and that, till the 20th century, double-outriggers were still to be seen in Madagascar and on the east coast of Africa. That their origin was Indonesian was clear to Haddon and Hornell from their Javanese lashings.

For constructing his replica, Beale had the assistance of a marine archaeologist, Nick Burningham, and assistance from the Indonesian government, interested in commemorating the 20th anniversary of the UNESCO restoration of the Borobudur temple. Beale commissioned Saad Abdullah, a ship builder from the Kangean islands, aged 69, to construct the 18 m long boat. It took six months for a team of 26 to build the wood and bamboo ship which was built without using a single nail.

On 15 August 2003, the ship left Java for the Seychelles. In Beale's words from his website, "We flew across in 26 days, an average speed of 5.3 knots for the 3500 miles" [25].

Fig. 4.3 The replica of the Borobudur double-outrigger which sailed from Java to Africa in August 2003 (photo courtesy Philip Beale/The Borobudur Expedition)

The speed of Beale's voyage confirms the prehistoric feasibility of the Cinnamon Route. It demonstrates the practicality of using a Halmaherian double-outrigger to harness the power of a major warm current flowing out of the WPWP to cross vast ocean distances. The success of Beale's replica voyage might be seen as providing indirect support for the claim that Spice Island mariners harnessed the power of two other major WPWP currents (the Kuro Shio Current and the East Australian Current) for transoceanic exploration, trading and migration in the northern Pacific Ocean and for colonizing New Zealand in the southern Pacific.

How much sail early Spice Island double-outriggers carried is unclear. Haddon and Hornell describe the Halmaherian double-outrigger as double masted. That the outriggers that sailed the Cinnamon Route had sails is certain for they depended on monsoonal winds for a fast passage. We have suggested that experiments in the design and use of sail would have arisen naturally both in the West Pacific Warm Pool long-distance voyaging nursery and later in sailing the Cinnamon Route. For swift passage, given the sheer distance without landfall on this ancient trading route and the associated risks of hypothermia, an effective use of sail would have been vital. And swift passage under sail would have been as important in sailing the comparable distance over the long stretch of ocean through which the Kuro Shio Current drove from the Spice Islands to Southern California.

4.7 Did Spice Island Mariners Follow Another Major Current from the West Pacific Warm Pool into the Indian Ocean?

We have argued that spice trading was fundamental rather than incidental to the maritime development of the Spice Island ancestors of the Polynesian peoples, that it was probably a driving factor in their evolution not only from local to regional trading but also to international maritime trading. Spice trading seems almost certainly to have been the motivation for Spice Islanders developing the sailing and exploration strategy of following at least two of the four major warm currents flowing out of the WPWP. The first current flowed through the volcanically heated WPWP to Japan where, we conjecture, Spice Islanders established an early trading colony. (Evidence for this is discussed in the next chapter.) The second made possible the establishment of the Cinnamon Route which conveyed spices to Africa from where they could be transshipped to the Middle East and Europe. Another major current flowed from the WPWP into the Indian Ocean.

The West Australian Current, as its name suggests, flowed south along the coast of Western Australia. Our paradigm predicts that Spice Island explorers would also have followed this current. Exploration and trading often go hand in hand, though the discovery of new territories does not always result in the opening up of new trading possibilities. For Spice Islanders, a second motivation for exploration seems to have been the quest for new territories to colonize as safe refuges against the possibility of invasion and tribal defeat. With continual destabilizations in the spice trade, possibly from 1500 BC, and later local and foreign attempts to wrest spice-growing islands from indigenous owners, searching for refuges in some periods may have become more important to some tribes than securing spice-trading opportunities and advantages.

There is slight but intriguing evidence that Spice Island mariners involved in sailing the Cinnamon Route may have followed the West Australian Current and explored the length of the Western Australian coast. It should, however, be stated at the outset that – with one exception – the evidence is tenuous in the extreme.

The first possible evidence lies with the presence on the northwestern coast of Western Australia of boab trees. By the test of maximum genetic diversity, it seems likely that Madagascar is the homeland of the boab tree: Madagascar has six species, Africa one and Western Australia one. It is possible for boab seeds to have reached Australia by ocean current (presuming that boab seeds can survive long immersion in salt water). But boab seeds would have to float from Madagascar to east Africa and then north along the African coast till the current turned and travelled back across the Indian Ocean to Java. Near Java the seeds would have to change currents so as to be drawn south along the Western Australian coast. It would have been important for them to do so for no great distance because they would have to be carried to a landfall on the northwest coast where a tropical climate could promote their germination and survival.

Unless such oceanic diffusion is measured over millions of years, it is more likely that voyaging Indian Ocean mariners sailing the Cinnamon Route carried boab seeds with them from Madagascar. Indian Ocean mariners are indeed known to have carried boab seeds on long voyages. Perhaps they had found that boab seeds, which are high in vitamin C, were an excellent preventer of scurvy. Given that spice traders had a vested interest in recognizing and exploiting the medicinal properties of plants, it is not improbable that Spice Island mariners may have brought boab seeds to Western Australia from Madagascar as food or scurvy-preventers. Contradicting this possibility is the fact that the Western Australian trees represent a different species of boab from those on Madagascar. Although species differentiation is accelerated in a new environment, a maximum of 3,500 years is probably not long enough to account for species differentiation. In the absence of adequate data we can only weigh up probabilities. We have either an ancient event involving oceanic dispersal (an event measured in millions of years) or a recent human dispersal of a species of boab now extinct in Madagascar or a very rapid species differentiation in Western Australia. We would need far clearer evidence than this to verify the possibility that Spice Island mariners sailing the Cinnamon Route may have followed another fast warm current flowing out of the West Pacific Warm Pool and explored along the coast of Western Australia.

There is a second source of possible evidence that involves the same assessment of probabilities for oceanic dispersal versus human dispersal, but in this second case we have the advantage of a radiocarbon date that may support the possibility of second-wave human dispersal.

In January 1993, a nine-year-old schoolboy, Jamie Andrich, found an egg of the now extinct Madagascan elephant bird, *Aepyornis Maximus*, in sand dunes just north of Cervantes, Western Australia, 250 km north of Perth. The egg was found a kilometre inland among ancient sand dunes that once marked the shoreline. In 1930, over 60 years earlier and 50 km closer to Perth, about 100 m from the sea another schoolboy, Vic Roberts, had found a smaller egg from the elephant bird at Scott River, Augusta. Like the smaller extinct New Zealand moa, the elephant bird was a ratite, a giant flightless bird 3 m tall. The elephant bird, which like the boab tree was indigenous to Madagascar, became extinct about 300 years ago. The circumference of the egg found in 1993 is 800 mm, its volume 7 litres.

In 1968 a Western Australian newspaper reported Robert's claim that at the time he found the egg he had seen at least part of a skeleton with a very large skull with a beak on it. Though he has often searched for it since, Roberts has been unable to locate the skeleton in the shifting sands of the dune where he found the egg. Both eggs are now held in the Western Australian Museum in Perth.

The second egg was radiocarbon dated to 2000 $\pm$ 75 years [26]. This dating, appropriate for second-wave exploration, at least suggests the possibility that it was brought from Madagascar for food or trade by mariners sailing the Cinnamon Route. Indeed, considering the southerly locations where both eggs were found, the dating would suggest that second-wave mariners, following the West Australian Current flowing south from the West Pacific Warm Pool, explored most of the length of the Western Australian coast.

But if, as Vic Roberts claims, a skeleton of the elephant bird existed alongside the egg, interpretation of his discovery becomes more complex. It might imply an attempt not by explorers but by colonists to breed elephant birds in Western Australia, to provide meat for consumption and bone for the manufacture of artefacts. In other words, the existence of a skeleton might imply a colonization rather than simply exploration of the Western Australian coast.

A third piece of evidence supports this possibility. Though again the evidence is unusual, human dispersal in this case is certain. In Chapter 5 we discuss the diffusion of the Moon/Lake myth which has a Spice Island origin and a Lapita distribution. The myth is found in the recognized Lapita colonies but it is also found in what we claim also to be early Spice Island colonies, New Zealand, Japan and Hawaii. The myth is not found in Eastern Polynesia. Apparently, anomalously, it is also found in an area inland from the Western Australian coast south of the Hammersley Ranges [27]. Ocean currents could account for the dispersal of boab trees to the northwestern coast of Australia, if it is established that boab seeds can survive long periods in salt water and if a very long time scale is allowed to explain species differentiation. Ocean currents might, with the same caveats, have brought elephant bird eggs and even a ratite skeleton to Western Australia. But the Moon/Lake myth, which has its origin in the Spice Island region, can only have reached Western Australia by human agency.

In terms of our paradigm the myth clearly has a first-wave (Lapita-age) diffusion in the Pacific: Japan, Vanuatu, Fiji, Samoa, Hawaii and New Zealand (supporting the prediction inherent in our paradigm for a Lapita-age first settlement of New Zealand). Its presence in Western Australia suggests that first-wave explorers or settlers brought the myth to Western Australia. If so, there is some evidence for both first-wave explorers and migrants following the West Australian Current south before 1000 BC. Conceivably second-wave explorers or migrants after 400 BC, again following the same current south along the Western Australian coast, could have brought at least one of the elephant bird eggs from Madagascar to Western Australia. Though myths were often spread by traders, and may imply only transient contact, it is conceivable that diffusion of the Lapita-age Moon/Lake myth to Western Australia might imply the setting up of an ancient settlement there.

While evidence for Spice Island mariners following the West Australian Current into the southern Indian Ocean in two different periods is tenuous and unusual, that it exists at all is remarkable.

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Chapter 5
Transoceanic Trade and Migration (2)

Following the Kuro Shio Current into the Northern Pacific: Colonizations of Micronesia, Southern Japan and Hawaii

Abstract Following the Kuro Shio Current into the northern Pacific provided a migration path for Spice Islanders which stands outside the simplistic paradigm in which the Lapita migrations are seen as the singular source for Pacific colonizations and in which the settlement of the Pacific is seen as following solely, directly and sequentially from the west–east colonizations of Near Oceania, Island Melanesia and Western Polynesia. In this chapter it is suggested that following the Kuro Shio Current led to a Spice Island colonization of western Micronesia about 5,700 years ago, possibly led to the early establishment of a colony in southern Japan at this time and certainly led to the setting up of a colony in southern Japan in the Yayoi period (300 BC–AD 300). Further, it is shown that there is traditional and archaeological evidence that Spice Island mariners following the Kuro Shio Current through the northern Pacific colonized Hawaii before 1000 BC.

Keywords Kuro Shio Current · Micronesia · Japanese colony · Japanese taro · Moon/Lake myth · Cosmogonic tree

5.1 Introduction

In the last chapter we began the cumulative substantiation of our central paradigm by considering the well-documented Cinnamon Route, an early transoceanic exploration, trading and migration route which clearly followed one of the four major currents flowing out of the West Pacific Warm Pool. For probably 500 years before the descent of the global cold period in c. 1000 BC and for at least a thousand years after it ended, there is evidence that mariners followed a major WPWP current from the Spice Islands to east Africa over a distance of more than 11,000 km, exploiting its clockwise loop to make return spice trading voyages through the Indian Ocean. We provided consilient evidence from many sources to support the historicity, range, consistent use and economic viability of the Cinnamon Route: historical evidence stretching back to Roman times for its existence as a trade route; maritime evidence from the survival to the present day in the Indian Ocean of the Halmaherian double-masted double-outrigger that sailed the route; and genetic evidence, based

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on the Malagasy's possession of a near-coalescent Polynesian motif, of Spice Island involvement with the route as early colonizers of Madagascar.

But the Cinnamon Route was probably not the first Spice Island transoceanic route exploiting a major WPWP current. The most likely contender for this role was the Kuro Shio Current, our focus in this chapter and in the next. In these chapters we substantiate two claims: that exploitation of the Kuro Shio Current as a trading, exploration and migration route played a central role in the exploration and settlement of the northern Pacific Ocean before 1000 BC and that, as our paradigm predicts, both first- and second-wave Spice Island mariners followed the Kuro Shio Current to its continental limit on the west coast of America.

We argue that following the Kuro Shio Current provided a second migration path for Spice Islanders which stands outside the simplistic paradigm in which the Lapita migrations are seen as the singular source for Pacific colonization and the settlement of the Pacific is seen as following solely, directly and sequentially from the late west–east colonizations of Near Oceania, Island Melanesia and Western Polynesia (Fig. 5.1). In this chapter we suggest that following the Kuro Shio Current may have led to a first-wave colonization of western Micronesia about 5,700 years ago, possibly led to the early establishment of a colony in southern Japan at this time and certainly led to the setting up of a second-wave colony in southern Japan in the Yayoi period (300 BC–AD 300). In Chapter 6 we consider evidence that the Kuro Shio Current led first-wave explorers and colonizers beyond Japan to Hawaii before 1000 BC and also before 1000 BC drew them to a landing in southern California. We discuss archaeological evidence from southern California which records first- and

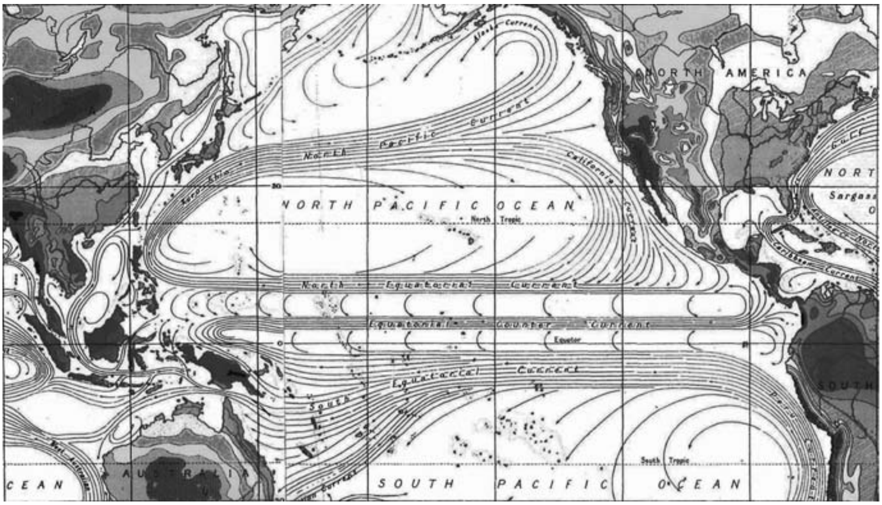

Fig. 5.1 The Kuro Shio Route showing the clockwise loop of ocean currents in the northern Pacific made by the Kuro Shio Current and the North Equatorial Current. (Based on a map of world ocean currents on pp. 12–13 of *The Times Concise Atlas*, Australian edition, 1976.) Copyright Times Newspapers Ltd and John Bartholomew and Son. Reproduced with permission from HarperCollins Publishers

second-wave contact with America before 1000 BC and after AD 300. In Chapter 8 we consider correlated botanical and archaeological evidence for the introduction of indigenous American plants to India between 1600 BC and about AD 1000 and discuss the possibility that Spice Island mariners may have been responsible for trading these plants across two oceans.

5.2 Some Evidence for a First-Wave Spice Island Colony in Southern Japan

J. Stephen Athens and Jerome Ward present palaeo-environmental evidence for initial colonization of Palau in western Micronesia during the middle fifth or even the sixth millennium BP. The earliest documented significant changes in pollen disturbance indicators and charcoal particle concentrations from Palau palaeo-environmental cores give dates for Babeldaob Island of around 4,200–4,300 cal. BP and for the smaller Ngerekebesang Island of 5,364 and 5,755 cal. BP [1]. Athens and Ward note that the dates indicating first settlement are "900 to 2300 years earlier than suggested by the earliest possible archaeological evidence" (p. 165). They are also 2,300 years earlier than the first Lapita settlements in Near Oceania and the probable earliest date for the establishment of the Cinnamon Route and first settlement of Madagascar. But they are more than a thousand years later than the earliest date Lamb cited for the undersea volcanic activity that led to higher SSTs within the WPWP and that we suggest led to the Spice Islanders' adoption of the WPWP as a long-distance voyaging nursery.

The suggestion that Palau may have been colonized as a rest and supply station on a trading route to Japan is not unreasonable, but finding archaeological evidence to support this is unlikely. There is, however, genetic evidence which supports the possibility of an early Spice Island colony in southern Japan: thereis evidence for a significant Indonesian genetic contribution to modern Japanese mitochondrial DNA [2]. A long time for genetic interaction with an established Japanese population would be required to allow for a significant Indonesian contribution of modern Japanese maternal DNA. As Spice Island colonists in any era would have been joining an established Japanese population, their genes could have made only a small contribution to the Japanese gene pool. But the earlier this contribution, the smaller the Japanese population would have been, and so the higher the percentage of Spice Island genes in the modern southern Japanese population. We suggest that the time required would be far greater than could be explained solely by the establishment of a second-wave colony in the Yayoi period (300 BC–AD 300).

Logically, given the importance of high SSTs for reducing the risks of hypothermia, a spice-trading route to Japan is the most likely early oceanic (as opposed to coastal) trading route to have been first followed by Spice Island mariners and, of the four major WPWP currents, the Kuro Shio Current is the most likely current to have been chosen as their first major exploration and migration path. For the route to Japan via Micronesia lies almost wholly within the WPWP, avoiding cooler waters beyond its margins. It is hardly surprising, then, that the earliest evidence for oceanic exploration and migration comes from Palau within the WPWP about 5,700 years ago. This evidence predates by 2,000 years the evidence for migrations from the Spice Island region to the Bismarcks and to Madagascar.

But the dating evidence for a possible first-wave Spice Island colony in southern Japan is elusive. We can speculatively tie it to the earliest evidence for the colonization of Palau and to the dating for the post-flood volcanic heating of the WPWP some time between 7,000 and 5,000 years ago. We can retrospectively suggest that there was a logical progression from the establishment of an earlier long-distance oceanic spice-trading route following a major current to southern Japan through the volcanically heated waters of the WPWP to the later establishment of an oceanic spice-trading route to east Africa through the colder Indian Ocean following another major WPWP current. And we can argue that the evolution of the double-outrigger, able to exploit both fast warm currents and wind power, was more important for meeting the needs of a trading route to Japan than it was for sailing the Cinnamon Route which could exploit a clockwise current loop. That is, we can argue on circumstantial grounds that the development of the double-outrigger and the evolution of skills involved in adopting the sailing strategy of following fast currents over long distances would most naturally have occurred first within the WPWP following its volcanic heating and that this would have led naturally to the establishment of an early oceanic spice-trading route to Japan.

The advantages of opening up a fast oceanic trading route to Japan through the WPWP close to 6,000 years ago are obvious. Not only would it have opened up a market for spices in Japan and perhaps in Korea but it may also have provided new opportunities for trading with Asia from a Japanese base following the drowning of vast areas of the eastern coast of China in the last Ice Age flood and the probable destruction of earlier coastal trading arrangements. We have seen how, analogously, perhaps 2,500 years later, the creation of the Cinnamon Route opened up a faster oceanic trading route through the Indian Ocean. It gave Spice Islanders, at a time of sharpened demand for their spices, the opportunity to establish a new fast means of access to the markets of the Middle East and Europe via the east coast of Africa.

We suggest that the motivation for the early colonization of Palau was most probably to create a rest and supply station for a spice trading route to Japan, just as the colonization of Madagascar may have been at least partly to provide a rest and supply stop on the Cinnamon Route. There is a clear differentiation, however, in terms of the maritime capability that this analogy suggests. The need for a rest stop in Palau only 900 km from Halmahera suggests an oceanic range far inferior to the 4,000 or so kilometres capably sailed between Christmas Island and Madagascar on the Cinnamon Route. The implication is that a Spice Island trading route to Japan via Palau would have been established very much earlier than the Cinnamon Route to east Africa via Madagascar. And the fact that the Cinnamon Route was sailed in winter through a cold ocean, unsupported by the volcanically elevated SSTs that would have supported an early oceanic trading route to Japan through the WPWP, supports this implication of a greatly enhanced Spice Island maritime capability and of greater cold resistance by the time of the founding of the Cinnamon Route. Again the implicit conclusion is that a spice-trading route to Japan via Palau would have been much older.

5.3 Evidence from the Japanese Taro

The case for an early Spice Island colony in southern Japan and the case which we develop at length in Part II for a Lapita-age first settlement of New Zealand are both strengthened by recent innovative genetic research by Mike Hendy of Massey University, New Zealand [3]. Just as the analysis of the haplogroups of Polynesian commensal animals has led to a new approach to the study of human migrations in the Pacific, Hendy has developed a new approach to the analysis of human migrations in the Pacific through the genetic study of commensal plants.

Hendy [3] has pioneered a new way of genetically fingerprinting plants through the study of "junk DNA" as a means of gaining a more complete picture of their genetic history. The DNA that is involved in selection by genetic drift covers the traces of its historical evolution. By contrast, Hendy believes, analysis of "junk DNA" can reveal a more complete phylogenetic record. Hendy has applied this approach to a study of the New Zealand taro.

Forty years ago Douglas Yen and Jocelyn Wheeler [4] established that one of the varieties of taro found in New Zealand had evolved from the Japanese taro. In 1968 they mapped the relationship of taro in the Pacific and Southeast Asia according to chromosome numbers. The tropical taro cultivars found in Eastern Polynesia, New Guinea, the eastern and southern Philippines and the Solomon Islands exclusively have a chromosome count of $2n = 28$. Japan, the Ryukyus, northwestern Philippines, eastern China, Timor, New Caledonia and New Zealand possess two varieties, one with a chromosome count of $2n = 28$ and one with a chromosome count of $2n = 42$. As Yen and Wheeler note, "The taro plant in its distribution has been associated inevitably with man because of its universal propagation by vegetative means" (p. 262). They comment that

> If we take mainland Asia as a point of embarkation, the data (Map 1) point to three lines of diffusion; two of 28- and 42-chromosome forms travelling northwards through the Ryukyus to Japan, and southwards through Timor and New Caledonia to New Zealand; the third exclusively of 28-chromosomes proceeding through northern Melanesia to Polynesia (p. 263).

Against the counter-suggestion that the 42-chromosome form in New Zealand may represent a European introduction, Yen and Wheeler argue that 42-chromosome specimens "(from Great Barrier Island and from Spirit's Bay in the extreme northern peninsula of New Zealand) cannot be ascribed confidently to possible transfer in European times" (p. 265). The 42-chromosome taro found in 1957 untended on the Cavalli Islands off the north coast of New Zealand similarly seems unlikely to be descended from a European import. Yen and Wheeler imply that the 42-chromosome form was early. They suggest that it may have been rare or absent when the 28-chromosome form was introduced to Eastern Polynesia. It is clear from the history of diffusion for the taro that the 42-chromosome form could not have been brought to New Zealand from Eastern Polynesia by medieval migrants.

Hendy's analysis shows that 2,000–3,000 years ago a differentiating mutation separated the New Zealand cultivar from the Japanese taro from which it derives. The New Zealand variant does not exist in Japan. Hendy's work has interesting implications for early Spice Island contact with both Japan and New Zealand. Transplanting a cultivar, especially to a significantly different environment, can trigger mutation and differentiation, driven by selective pressures for adjustment to a new latitude, a new climate and growing conditions. Whether the mutation Hendy records came from a rare chance seedling or was a sport or somatic mutation is unclear but genetically it was probably a rare event. In Parts II and III we argue for a Lapita-age first settlement of New Zealand and in Chapter 20 establish that it probably occurred close to 3,400 years ago. The descent of a global cold period about 3,000 years ago would have brought additional selective pressures for the Japanese taro's adaptation to the colder conditions and higher latitude of New Zealand. That the differentiating mutation occurred in New Zealand seems probable, given that the New Zealand cultivar is not found in Japan and given the extreme selective pressures that the Japanese taro would have encountered especially during the global cold period in New Zealand (about 400 years after first settlement by our calculations). In Chapter 7 we provide evidence of the sophisticated knowledge and awareness of early Spice Island horticulturalists and argue that their horticultural expertise was vital to their success as colonists, enabling them to establish horticultural systems on depauperate Pacific islands that made it possible for them to support significant human populations. That Spice Island colonists brought a form of taro to New Zealand that was already adapted to the higher latitude (34°N–35°N) and colder climate of Japan increased its chances of being successfully acclimatized to the colder conditions and higher latitude (40.5°S–48°S) of the South Island of New Zealand, which traditional accounts show was the first part of New Zealand to be settled (see Chapter 16). Later introductions to Western Polynesia and Eastern Polynesia of taro cultivars which were long acclimatized to tropical conditions similarly reflect a persistent history of aware horticultural practice.

Hendy suggests how studying the phylogenetic history of commensal plants might cast new light on the migration history of humans responsible for their dispersal. He suggests that in the case of the taro the 10% variation in the nested tandem repeat phylogenies of a New Zealand and a Japanese cultivar "suggests the rate of duplication will be a marker sufficient to measure relative times of the introduction and trade of this crop across the world". He notes that a project to do this is underway and that it is also possible that ancient DNA may be extracted from some archaeologically dated grinding tool to help calibrate this clock. Applying this new approach for studying the path through the Pacific of plants such as the sweet potato, cotton, plantain and gourd, which have all been foci in debates relating to transoceanic diffusion between Asia, Polynesia and America, may well be rewarding. The possibility of timing migrations using this technology extends the potential power of the approach.

One possible implication of Hendy's study of the Japanese taro is that Spice Island mariners may have sourced the 42-chromosome form of the taro directly from Japan and introduced it to New Zealand before 1000 BC, the earlier margin for its mutation and also the cut-off point for oceanic voyaging which was determined by the global cold period that began at this time. This provides us with a minimum age, if not for a first-wave colony in southern Japan, at least for Spice Island trading with Japan. The presence of the Japanese taro in New Zealand supports our claim for a Lapita-age first-wave settlement of New Zealand – with New Zealand like Japan being reached by following a major WPWP from the Spice Islands. But though the fact that the Japanese taro was taken to New Zealand may support the likelihood of a preceding first-wave settlement in southern Japan it cannot tell us how much earlier that settlement may have been.

Other contextual evidence for a first-wave Spice Island trading colony in southern Japan relies on archaeological evidence for both first- and second-wave Spice Island colonizations of Hawaii and contact with America. Again, while this evidence establishes the likelihood that there was a first-wave Spice Island colony in southern Japan, it can only supply later dating margins for such a colony. The distance from the Spice Islands to southern California enforces the likelihood that southern Japan was used as a rest and supply base on the Kuro Shio route from the Spice Islands to America in the earlier as well as in the later period. Given this likelihood, the clear dating we have for Spice Island contact with America in both periods, from before 1000 BC and from about AD 300 to AD 800 (discussed in the next chapter), carries implicit dating margins for both first-wave and second-wave southern Japanese colonies. If a colony was set up in Palau in Micronesia nearly 6,000 years ago to act as a rest and supply station for a spice trading route to Japan; if Japan in turn was used as a rest and supply station making possible the first-wave discovery and colonization(s) of Hawaii; and if Hawaii in turn was used as a rest and supply station enabling Spice Island explorers to reach America before the cold period descended in 1000 BC, we have a chain of circumstances that supports the establishment of a first-wave colony in southern Japan before 1000 BC. But the dating for this colony would need wide margins. The earliest date for the settlement of Micronesia is nearly 3,000 years earlier than the dating for the single-piece curved shell fishhooks which appear in southern California in about 1000 BC or slightly earlier and which, being common to both Micronesia and Hawaii as well as to southern California, establish both the Kuro Shio route and the timing for their diffusion.

But again this contextual evidence can only establish late margins for a first-wave Japanese colony. The argument for a time differential between establishing a spice trading route to Japan that was supported all the way by the warm waters of the WPWP and establishing a trading route across the colder Indian Ocean probably applies also to voyaging outside the Pool across the width of the northern Pacific. The differential implies that a spice-trading colony may have been established in southern Japan long before first-wave Spice Islanders reached Hawaii and America.

5.4 Evidence for a Second-Wave Spice Island Colony in Southern Japan

In contrast to these wide margins and the indirect and circumstantial evidence on which dating for an earlier colony depends, Ann Kumar and Phil Rose have presented evidence from many sources for a far more tightly dated second-wave colony in southern Japan [5]. The evidence they gather has been used to support a specific claim for the establishment of a Javanese kingdom in southern Japan in the Yayoi period (300 BC–AD 300). It is hardly surprising that it is easier to find dating evidence for the establishment of a second-wave colony in southern Japan than for a colony that may have been established there 2,000 or 3,000 years earlier. In terms of our paradigm, the return to global warmth after about 400 BC in the southern hemisphere, and possibly a little later in the northern hemisphere, provides the early margin for a second-wave Japanese colony. For a later margin, a possible date is supplied by traditional evidence showing that the Kuro Shio Current was still being used as a major migration and exploration path in AD 460 when, by our calculation (see Chapter 19), Irapanga led a migration fleet of six canoes to Hawaii from the Spice Islands (see Chapter 19). Recent archaeological and linguistic evidence presented by Terry Jones and Kathryn Klar for second-wave Polynesian contact with America between AD 300 and AD 800, however, extends this margin [6]. That both Japan and Hawaii would have acted as rest and supply stations en route to southern California in both periods seems probable. And it also seems probable that, as elsewhere in the Pacific, a second-wave colonization of southern Japan followed an earlier colonization.

Kumar and Rose's evidence for a Javanese kingdom in southern Japan in the Yayoi period accords with the early margins for second-wave colonization, although it fails to match the later margins suggested by traditional evidence and by the American archaeological evidence that we shall consider in Chapters 6 and 8. Some of the evidence Kumar and Rose consider is specific and clearly dates to the Yayoi period, but much of it is undifferentiated chronologically and, we believe, can just as reasonably be used to argue for the existence of an earlier Spice Island colony in southern Japan.

Kumar and Rose call on evidence from a range of sources: craniometric, cranioscopic, dental, genetic, archaeological, horticultural, linguistic and cultural. The evidence is tied to Indonesia generally and Java specifically [2, 5]. This is largely because Kumar and Rose chose available Javanese and Japanese written records from the Yayoi period as the material base for establishing linguistic evidence for an Indonesian/Japanese connection. Some of the archaeological evidence Kumar cites – for example, the similarity between Javanese krises and Japanese swords of the Yayoi period and similarity in accession rites in Java and Japan – also appear to be specific to Java and to the Yayoi period, but most of their evidence cannot be chronologically differentiated: notably the craniometric, cranioscopic, dental, genetic and cultural evidence linking Indonesian and Japanese populations. This evidence appears to support significant genetic and cultural interchange between colonizing Spice Island populations and established Japanese populations over a longer period than is allowed for solely by a second-wave colony in the Yayoi period. It seems unlikely that establishing such a late colony would have allowed time enough to account for the observed morphological and genetic similarities between Indonesian and Japanese populations. This is especially so given that Spice Island colonists in both late first-wave and second-wave periods would have represented such a tiny proportion of the existing southern Japanese population that they joined that their genetic and morphological contribution to that population would have been minimal. Indeed, one would expect their genes and morphological characteristics to have been mostly submerged or lost. That this is not the case, we believe, is an argument for earlier contact.

It is interesting that the genetic evidence Kumar cites involves mitochondrial DNA for this implies not merely trading contact with Japan but the establishment of a colony or colonies allowing for significant interactions over time between Indonesian female colonists and Japanese men. As we have noted, recurrent visits by male spice traders would have left no imprint on Japanese mitochondrial lines. Kumar points to the existence in modern Japanese maternal lines of three mitochondrial sites (243, 325 and 136) shared only by Japanese, Indonesians and in one instance Koreans. Considering the morphological evidence, Kumar argues that "Taken together, these morphological studies reveal significant support for the idea of a southern and most likely Indonesian group among the Yayoi" (pp. 269–270). Considering mitochondrial, dental, craniometric and cranioscopic evidence together, she argues further

> The material surveyed here provides enough indications from a number of different areas to suggest that Turner's "dual origin" hypothesis ("Sundadont" Joman population + "Sinodont" Yayoi population) should be replaced by a "triple origin" hypothesis: that the present day Japanese population is the result of a three-way mixture consisting of the Jomon population plus two different groups of immigrants in the Yayoi period, one of which is of Indonesian origin (p. 273).

While the morphological and genetic evidence Kumar cites convincingly links Japanese and Indonesian populations, it may well indicate first-wave as well as second-wave interactions between the two. Yet aside from the circumstantial dating evidence inherent in an early settlement of Palau, the dating margins for a first-wave Japanese colony remain elusive.

5.5 Linguistic, Archaeological, Horticultural and Cultural Evidence

As well as drawing on morphological evidence, Kumar provides linguistic, cultural, archaeological and horticultural evidence to support her case for an Indonesian colony in Japan in the Yayoi period.

A second paper, co-authored by Phil Rose [5], a forensic phonetician, able to use sophisticated statistical techniques to match voice samples, adds linguistic evidence to support Kumar's hypothesis that Indonesians may have set up their own kingdom in Japan in the Yayoi period. The linguistic data demonstrates that the parallels between Japanese and Malayo-Polynesian could not be due to chance. Kumar and Rose show that

> The phonological correspondences map unidirectionally from Old Javanese to Old Japanese, and a search for cognates in all Austronesian languages covered by the major comparative dictionaries reveals that the lexical items are localized to the Indonesian subarea of Malayo-Polynesian. This points to one or more Indonesian languages as the source of the borrowings. The agreement between semantic and archaeological evidence on material and spiritual culture dates the contact to the Yayoi period (p. 219).

In arguing for the establishment of an Indonesian kingdom in Japan in the Yayoi period, not only do Kumar and Rose demonstrate strong linguistic connections between Indonesian languages and Japanese, but they also demonstrate clear archaeological connections and use these to date the kingdom to the Yayoi period. Similarities between Javanese krises and Japanese swords and Javanese and Japanese accession rituals, for example, are used to establish the Yayoi period for the Indonesian colony.

Kumar points to remarkably specific cultural and mythological links, describing

> a specific and detailed set of mythological correspondences in kingship rituals between Japan and Indonesia. For example, in both cases the central myth and ritual of kingship revolves around the moon maiden, associated with rice, whose robe the ruler must assume upon accession, and who, when she has returned to heaven, can be summoned by a burnt offering on the part of the ruler. In both cases, there is a sacred dance dedicated to the goddess, performed at accession and associated with the ritual numbers 4/5 and 8/9. It is important to emphasize the high degree of specificity in the correspondences (p. 221).

Additionally Kumar and Rose cite horticultural evidence in support of these cultural links:

> it has been demonstrated (Moinaga 1968, Olia 1988: 145–148) that Japanese rice and Javanese (javanica) rice – the third major subdivision alongside the Chinese (sinica) and Indian (indica) – are more closely related to each other than either is to any other types of rice. Javanica rice originates in Indonesia (p. 221).

But far older cultural and horticultural links appear to underlie the specific correspondences Kumar and Rose describe as belonging to accession rituals in the Yayoi period. These suggest significant contact in a far earlier period. Recent suggestions that rice-growing might have originated in Southeast Asia and spread from there to southern China, for example, support the possibility of a pattern of flow for rice cultivation from equatorial regions to ones of high latitude, rather than the other way around. Oppenheimer [7], for example, notes that "Thai archaeologist Surin Pookajorn has found rice grains associated with pottery and other Neolithic artefacts such as polished stone adzes in Sakai Cave" on the Malay peninsula (part of the continent of Sundaland before the last Ice Age flood) dated to between 9,260 and 7,620 years ago. Closer to the Spice Islands, Oppenheimer notes that "The earliest site with evidence for agriculture is 5150 years old from Gua Sireh (Borneo), followed by Ulu Leang in Sulawesi 5100 years ago" [7].

The Sakai Cave on the Malay peninsula is only about 10°N of the equator (whereas southern China – where rice was thought to have been first domesticated –

lies between 20 and 30°N). Sirah Cave in Borneo is about 2°N of the equator and Ulu Leang in Sulawesi a little over 3°S of the equator. If rice were first domesticated in Southeast Asia, major acclimatization would have been needed for rice to grow in southern China and in Japan because of sharp differences in the ripening times between equatorial and high-latitude areas. It is therefore more likely, given that a significant time would have been needed for its acclimatization there, that first-wave rather than second-wave Spice Island colonists introduced rice to Japan. A long history of plant domestication in Wallacea, as we shall see in Chapter 7, would have given even first-wave Spice Island colonists the horticultural skills to genetically manipulate its acclimatization to the higher latitudes of southern Japan. If rice was important to the accession rituals of the Yayoi period, rice was probably an important staple then: not recently imported but long acclimatized.

If the horticultural background to the accession myths, which was shared by the Javanese and Japanese in the Yayoi period, dates back to an earlier period, so too does the mythological background for the accession rites. We can date the Moon/Lake myth to the period of first-wave colonization because in the Pacific it has a Lapita-age maritime distribution which provides a later margin for such dating (3,600–3,000 years ago). An earlier margin is given by the likely diffusion of the myth through a mainly land migration to Europe from the Spice Island region via the continent of Sundaland before the last Ice Age flood drowned the continent and this migration path 7,500 years ago. The land diffusion via Sundaland took the myth to Turkey, Greece, Germany, England and Scandinavia and matches the diffusion of the Spice Island myth of the Cosmogonic Tree or Tree of Life which reached Europe by this same land route and which also has a Wallacean origin and a Lapita distribution in the Pacific.

The geographical diffusion of the Moon/Lake myth – to Japan, Hawaii, New Zealand and Western Australia – as well as to the recognized Lapita colonies of Vanuatu, Fiji and Samoa, fits with a Lapita-age first-wave diffusion of the myth. Such a diffusion accords with our paradigm which predicts that Spice Islanders would have followed the Kuro Shio Current to Japan and Hawaii in the east, the East Australian Current to New Zealand and the West Australian Current to Western Australia in the south. Significantly the Moon/Lake myth is not found in Eastern Polynesia which was settled perhaps 1,500 years later. Nor is it found in North or South America.

5.6 The Moon/Lake Myth and the Myth of the Cosmogonic Tree

As a prelude to discussion of the distribution of the Moon/Lake myth, it is helpful to quote the Javanese and Japanese versions of the myth narrated by Oppenheimer [8]:

> In Java there is the following story: the moon goddess Nawang Wulan (Wulan = month) descends to Earth having donned her swan-feather cloak. She lands on the waters of a lake, where she discards her cloak and begins to bathe, but the cloak is stolen by Kyai Agung. When she cannot find her means of returning to the sky, she is obliged to stay with the man,

> so she marries him and they have a daughter, Nawang Sih. The goddess generates rice for the household using her magical powers and Kyai Agung is expressly forbidden to look in the pot where the rice is stored. One day curiosity overcomes him and he discovers that the pot only contains a single grain of rice. Now the magic will work no more and the goddess is forced to collect and pound rice each day as would a mortal wife. She does however find her swan cloak and uses it to fly back into the sky. At night she stays there, but during the hours of daylight she returns to earth to be with her husband and child (p. 341).

The Japanese version is simpler:

> A fisherman once found a robe of white feathers on the beach. No sooner had he picked it up than a beautiful shining girl emerged from the sea, begging him to restore her property, for 'Without my plumage I cannot go back to my home in the sky. If you give it back to me I will sing and dance for you.' The fisherman returned to her the lovely robe of feathers. She put it on, took her lute, and sang a hymn to the Moon, where she had her palace. Gradually as she danced she rose up into the sky, then she unfolded her white wings and flew away to the full Moon (p. 343).

Oppenheimer sources the Moon/Lake myth not to Java but to Wallacea. Both the Spice Island myth of the Cosmogonic Tree, or Tree of Life, discussed in detail in Chapter 17, and the Moon/Lake myth are concerned with accessing supernatural power. The heavens are seen as the source of such power. The Cosmogonic Tree has the power to act as a bridge between the heavens and earth and so to bring fertility to crops. In Japan the ruler at accession donned the robe of the Moon Maiden, thereby taking for himself her supernatural power and most especially her power to move between earth and heaven. In Japan a burnt offering enabled the ruler to summon the Moon Maiden herself at need.

It is interesting to note that accession rites in Japan's neighbour Korea were associated with the Cosmogonic Tree, a white birch seen as the centre of the Cosmos. It has some similarity with the Norse World Tree, Yggdrasil, the huge ash tree whose branches stretched over heaven and earth and which had three great aerial roots passing down from the tree. In Korea accession rites were associated with the Cosmogonic Tree till AD 527 when Buddhism became the state religion. The Cosmogonic Tree, for example, appears on all the major crowns found in Silla tombs (ancient Silla being dated from about AD 400 till AD 500) [9]. One of these crowns on display in the Korean National Museum shows seven branches of the tree, indicating that the ruler could travel through seven levels of heaven. Accession rites asserted the shamanic power of the ruler, who was seen as able through his contact with the Cosmogonic Tree, to travel between earth and heaven and to access power from all levels of heaven.

We suggest that some of the Japanese–Indonesian links, linguistic, genetic, agricultural, ritual and mythological, that Kumar and Rose discuss are almost certainly older than the Indonesian colony that Kumar dates to the Yayoi period. As we have noted, the myths of the Cosmogonic Tree and of the Moon/Lake both reached parts of the Middle East and Europe by land possibly before the last Ice Age flood. In the Pacific, as we have seen, these myths have a Lapita distribution. Links between the Spice Islands and Japan far earlier than the Yayoi period are predictable from the oceanographic and maritime history of the ocean region between the Spice Islands and Japan. That, as Kumar and Rose establish, culturally the two areas were still powerfully connected in the early centuries BC and AD through a Yayoi colony suggests the continuing importance of the Kuro Shio Current. Traditional records of several second-wave colonizations of Hawaii from the Spice Islands via Micronesia, including Irapanga's migration to Hawaii in about AD 460, serve also to establish the long life and the continuing importance of this trading and migration path.

There is further evidence for both first-wave and second-wave Spice Island colonies in southern Japan implicit in the archaeological evidence detailed in our next chapter. There we present clear archaeological evidence from southern California for first-wave Spice Island contact with America before 1000 BC and archaeological and linguistic evidence for second-wave contact after about AD 300. Southern California is the landfall to which the Kuro Shio Current would have carried a double-outrigger voyaging from the Spice Islands to the east coast of America via Micronesia, Japan and Hawaii. That the Kuro Shio Current was an exploration, trading and migration path for a very long time is clear. And that both Japan and Hawaii would have acted as rest and supply stations en route to southern California in both periods seems probable.

In Chapter 4 we presented evidence from oral traditions preserved in both Hawaii and New Zealand for both first- and second-wave migrations to Hawaii and mentioned the exploratory voyage to Hawaii by Maui the Navigator recorded in Maori traditions. Three hundred and sixty years later a migration fleet of six canoes was led by Maui's descendant Irapanga, following the Kuro Shio Current from the Spice Island region through Micronesia to Hawaii. This migration can be dated from a Rarotongan genealogy to about AD 460 (see Chapter 19). Tradition tells us that these migrants settled on the island of Oahu in the Hawaiian group. Evidence in the next chapter for technological diffusion along the Kuro Shio route which involves all three staging posts – Micronesia, Japan and Hawaii – offers consilient substantiation for the early and later colonizations of Hawaii recorded in tradition. Our circumstantial case for a very early first-wave Spice Island colony in Japan possibly 5,700 years ago suggests that the Kuro Shio Current could have been used as an exploration, trading and migration path for over 4,500 years.

5.7 A Summary

Neither the Spice Island colonizations of Japan nor of Madagascar have been a significant focus for Pacific researchers but both are clearly part of the wider pattern of Lapita-age maritime colonizations from the Spice Island region, to which the colonizations of Micronesia, Remote Oceania, Island Melanesia, Western Polynesia and, we shall argue, New Zealand belong. That both Japan and Madagascar along with Hawaii and New Zealand could be reached by exploiting fast warm currents flowing out from the West Pacific Warm Pool is significant and supports the paradigm we develop that shows how the primary sailing and exploration strategy of following currents flowing out from the West Pacific Warm Pool determined major migration paths used in the early settlement of the Pacific and of Madagascar in the Indian Oceans.

It seems clear that the continued history of maritime migration, both within and beyond the Spice Island region, triggered by conflict and defeat, was related to the spice-trading history of the region. Perhaps, we have suggested, such conflict was even determined by periodic surges in the international demand for spices and by corresponding conflict and destabilizations of the spice trade. Certainly tradition confirms that tribal defeat in battle was nearly always the trigger for more dangerous distant oceanic migrations. An ancestral expression captures the risk-laden impasse faced by such immigrants: “If we stay we die. If we go we die. Let’s go!”

The Spice Islanders’ possession of unique and valuable spices gave them a trading resource of enormous value. It is easy to imagine the impetus this would have given the Spice Islanders, from their earliest history, to develop the maritime skills and technologies needed for them to advance from local to regional to inter-regional and international spice trading. By the time of Maui the Navigator’s visits to New Zealand and Hawaii, in about AD 100 by our calculation (see Chapter 19), spices from the Spice Islands and the Indonesian archipelago were already reaching the Roman Empire and Europe. Eventually through the far-flung extent, road systems and maritime organization of the Roman Empire and its trading connections, spices would become a prized luxury across much of the known world and hold that place till the late 18th century.

We have suggested that although, arguably, the spice trade shaped world history – most obviously in the last 2,000 years – it may also have shaped a long local history of conflict in Island Southeast Asia that may have triggered the initial Lapita expansions into the Pacific and possibly numerous subsequent expansions, of which the initial and possibly subsequent colonizations of Madagascar, Japan and Hawaii are examples. A Lapita-age first settlement of New Zealand and the colonizations of New Zealand by Maui and successive descendants of Maui over the next 700 years, which are recorded in tradition, may fit the same pattern.

Prehistorians tend to see the expansion of the so-called Lapita peoples, though extending over 500 years, as the sole expansion from Island Southeast Asia. A Spice Island background challenges this. Polynesian, and presumably proto-Polynesian, societies are and were tribal. Warfare centring on possession of the Spice Islands may have taken place between proto-Polynesian tribes as readily as between such tribes and the invading lanky blackskinned foreigners described in oral traditions. There may have been a long anterior history of conquering tribes being forced to migrate. The whare wananga oral traditions suggest this: the earliest of the successive migrations recorded in these traditions seem to have been within the Indonesian archipelago.

We have suggested that tribal conflict in the Spice Island region was perhaps encouraged in the early centuries AD by foreign traders seeking to gain control of spice sources. This historical context throws light on Maui the Navigator’s exploratory voyages to New Zealand and Hawaii, seeking possible refuges for his people in the case of future defeat, and confirms our reading in Chapter 16 of the oral traditions of Maui’s visit to New Zealand with its oblique recording of the conflict in Hawaiki (the Polynesian homeland). Continuing migrations over centuries by Maui's descendants, by his grandson Wi-Wi, and Wi-Wi's great-grandson Tutumaiao and considerably later by their descendant Rakaihautu, suggest the possibility of continuing enforced migrations to New Zealand from the Spice Island region.

The question of when Madagascar was first settled, and how many migrations may have followed, may never be answered. But the factors triggering its settlement belong both to global climate history and to the history of conflict, to which the Spice Islands were exposed as soon as warmer SSTs gave foreign traders access to the Spice Islands. The arrival in the area of Indian, Malay, Chinese and Arab traders in the 1st century AD can only have magnified the risks of conflict in the region and magnified the risks of spice-growing islands being seized from their indigenous owners, risks that tribes in the region may already have confronted for millennia. The establishment of the Cinnamon Route and the colonization or colonizations of Madagascar are part of the maritime history of the region, which was subject not only to climate constraints but also to the local, regional and international pressures that shaped the history of the Spice Islands and the history of spice trading for millennia and that drove migrations both within and from the region.

Considering the migration history of Madagascar establishes the pattern for some of the early and perhaps most of the later long-distance migrations from the Spice Islands and the Spice Island region – notably for migrations to Japan, Hawaii and New Zealand. All these migrations exploited fast warm currents flowing out of the WPWP and all were subject to the same climate constraints. The need for high SSTs to avoid hypothermia limited these migrations to warm global climate periods. Though spice trading was a driving motive for earlier migrations, tradition suggests that many of those who later migrated were subject to conflict and the risk of defeat in their spice-trading homeland.

That there is evidence, from several contexts, for the establishment of an Indonesian colony in Japan in the Yayoi period is important to an understanding of the colonizing background to which the Lapita migrations belong. Instead of viewing the Lapita expansion into Remote Oceania as an isolated phenomenon, we can see it rather as part of a continuing wave of trading and colonizing expansions from the Spice Islands. Supported by the Kuro Shio Current, this expansion extended eastwards from Japan with several migrations from the Spice Island region to Hawaii in the northern Pacific. There is traditional evidence for at least the discovery of Hawaii before 1000 BC and, as we shall see in the next chapter, there is also evidence that first-wave Spice Island mariners reached southern California in this early period. There is clear evidence from tradition for several second-wave migrations to Hawaii after 300 BC and again archaeological evidence that Spice Island mariners, following the Kuro Shio Current to its terminus beyond Hawaii in this later period, again reached southern California

The distance from the Spice Islands to southern California via Japan might be thought of as being far too great to have been sailed by prehistoric mariners. It might be thought especially unlikely that Spice Island mariners could have reached America before 1000 BC. In fact the distance is little different from the distance from the Spice Islands to Rhapta in east Africa, a route we know was repeatedly sailed over the thousand years from about 400 BC to AD 600 and which was probably established 3,500 years ago. Spice Island voyaging achievements in two oceans across ocean distances close to 11,000 km over 3,000 years ago not only provide strong support for our paradigm but also invite recognition of the early voyaging skills of the Spice Island ancestors of the Polynesian peoples and a radical reassessment both of their early maritime history in Island Southeast Asia and as explorers and colonizers of the Pacific. Our knowledge of the Cinnamon Route comes partly from historical records. Evidence for Polynesian contact with America depends on linguistic and archaeological evidence. This is our focus in the next chapter.

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Chapter 6
Transoceanic Voyaging in the Pacific

Following the Kuro Shio Current to America

Abstract This chapter provides evidence for the fulfilment of what many would see as the most extreme prediction of the central paradigm of the book: the prediction that Spice Island mariners, in two periods separated by the 600-year global cold period after 1000 BC, followed the Kuro Shio Current to its continental limit on the southern coast of California. There is archaeological evidence for Spice Island contact with America in both periods and there is evidence for pre-Columbian introductions of the Polynesian chicken to America. Cultural complexes associated with chicken introductions are seen to be linked to the timings of introductions, to the ultimate origins of the chicken lineages involved and to diffusion paths for those lineages within America.

Keywords Pre-Columbian contact · Chicken in America · Cultural complexes · Diffusion paths

6.1 Introduction

Our main task in this chapter is to demonstrate the soundness of the central paradigm of our book by providing evidence for the fulfilment of what some would see as its most extreme inherent prediction: the prediction that Spice Island mariners, in two periods separated by the 600-year global cold period after 1000 BC, followed the Kuro Shio Current to its continental limit on the southern Californian coast. The task is overshadowed by the diffusionist/anti-diffusionist debate that has bedevilled American anthropology for more than a century. There is a long history of controversy surrounding the possibility of sustained Chinese contact with prehistoric America. While some prehistorians and archaeologists argue for an independent evolution of American prehistoric civilizations, others claim a long history of Chinese influence. Chinese influence is seen by diffusionists as contributing to, and even fundamentally determining, the evolution of those civilizations. Those arguing for independent evolution reject the possibility of transpacific contact. Suggestions of associated technological

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diffusions are bitterly contested. The debate creates an emotionally charged context for discussions of prehistoric Polynesian contact with America.

Diffusionists have always regarded the Kuro Shio Current as the maritime route for a diffusion of technologies from China to America. In this chapter, in studying the pre-Columbian introduction of the Polynesian chicken to America, we consider evidence for the introduction of the melanotic chicken to Mesoamerica along with an associated Chinese shamanic/medical complex. Doing so involves us directly in the diffusionist debate. Though our discussion of diffusionism is largely postponed until Chapter 8, it is nevertheless obvious that in the process of substantiating our paradigm we provide a new context in which the cultural and artistic diffusion of Chinese technologies and styles to America can usefully be reconsidered. For not only do we establish the prehistoric maritime viability of the Kuro Shio route but we establish that not one but two transoceanic routes of similar length, exploiting the same oceanographic mechanism, were followed by Spice Island mariners for millennia in two oceans. Their feats effectively reinforce the likelihood that, like Spice Island mariners, Chinese mariners may have used the Kuro Shio Current as an exploration and trading path over as great a time span. This parallel is reinforced by evidence that Chinese voyaging to America, dating from about 1450 BC, was also interrupted for 600 years by the global cold period that began in about 1000 BC [1].

6.2 Archaeological Evidence for Spice Island Contact with America

The earliest evidence for Polynesian contact with America was proposed by John Dunmore Lang in 1877 [2]. In the light of our paradigm and the role it ascribes to the Kuro Shio Current, it is not surprising that this evidence focuses on Polynesian contact with southern California. For southern California is the landfall predicted by our paradigm, the landfall to which the Kuro Shio Current would draw mariners following the current eastwards from Japan.

Lang saw similarities between Hawaiian and Californian single-piece curved shell fishhooks dated to before 1000 BC as an indication of ancient cultural contact between Polynesia and America. Reopening the debate on diffusionism in 2005, Terry Jones and Kathryn Klar [3] discuss the case for a Micronesian or Hawaiian origin for these Californian single-piece curved shell fishhooks. They summarize the challenges suggested by anti-diffusionists such as Reinman (1968) who suggested "that a migrating fish could have carried at least a single hook between Polynesia and the New World" and Strudwich (1986) who argued "for independent invention of these stylistically simple implements in the different areas of the Pacific". They comment on the similarities that previous scholars have noted between these fish-hooks "with those from Micronesia (Kirch 2000: 180) and Hawaii (Emory et al. 1968: Plate 1, 65–68)" and note the sudden appearance of a new technology:

> For at least 7000 years, line fishing was pursued in southern California solely with bone gorges and simple compound hooks. These implements were supplemented with

> single-piece curved shell fishhooks between 1000 B.C. and 500 B.C. (Glascow 1996: 134); Koerper et al.1995; Rick et al. 2002) or perhaps slightly earlier (Raab et al. 1995; Strudwick 1985).

Ironically, however, in a paper presenting a case for diffusion, Jones and Klar accept the modern rejection of evidence for this early diffusion, noting that "the chronology of single-piece shell hooks in California (ca. 1000 B.C.) is considerably earlier than the settlement of the remote outposts of Polynesia, which is antithetical to the pattern of Polynesian colonization of the Pacific from west to east" (p. 466). Jones and Klar were clearly daunted by the date proposed for the earlier Polynesian contact.

Our central paradigm offers a new context in which to review this disputed evidence. Evidence for the appearance in southern California of a single-piece curved shell fishhook before 1000 BC and the attribution of these new fishhooks to Micronesia and Hawaii support a first-wave introduction and a Kuro Shio route for this technological diffusion. The evidence Jones and Klar provide for a change in technology following a 7,000-year period without change offers striking support for our interpretation of this evidence.

Our paradigm provides a route independent of supposed Eastern Polynesian involvement and a timing that accords with other first-wave Spice Island explorations before 1000 BC following powerful warm currents flowing out of the West Pacific Warm Pool. The early date for the settlement of western Micronesia, rather than late dates for the settlement of Eastern Polynesia, provides the relevant external defining chronological boundary as does dating for the global cold period that halted voyaging in 1000 BC. The dating of the Californian fishhooks has not been challenged. In the context of our paradigm, their appearance in southern California before 1000 BC provides evidence for a "first-wave" voyage of exploration that followed the Kuro Shio Current to a terminus in southern California.

Our paradigm also provides a new context for Jones and Klar's own evidence for Polynesian contact with America in the early centuries AD. Jones and Klar present a carefully argued case for such contact. Combining archaeological and linguistic evidence, the case they present provides clear support for our claim that second-wave as well as first-wave Spice Island mariners followed the Kuro Shio Current to a landfall on the coast of southern California. Their evidence has, however, been challenged.

The anti-diffusionist arguments made against Lang's evidence for Polynesian contact with southern California before 1000 BC – independent evolution of the technology and the impossibility of early contact between Polynesia and America because Eastern Polynesia was settled too late for such contact to have occurred – resurface in Atholl Anderson's case against later direct contact between Polynesia and southern California [4]. Jones and Klar focus on linguistic and archaeological evidence relating to the adoption "sometime between ca. AD 400 and 800", by Chumashan and Gabrielino speakers from southern California, of sewn-plank boat technology (common in Island Southeast Asia and Micronesia in the early centuries of the first millennium AD). They argue that there is evidence at the same time for "punctuated adaptive change (e.g., increased exploitation of pelagic fish)" associated both with the new boat technology and the appearance of a Polynesian style two-piece bone fishhook in the Santa Barbara channel in about AD 300.

Jones and Klar's evidence for sudden significant technological change in the period belonging to first-wave contact is matched by evidence for significant technological diffusion following second-wave Spice Island contact:

> After the end of King's Phase M3 (A.D. 300) and by the beginning of Phase M5 (A.D. 900), compound hooks show an intriguing stylistic change toward hook parts made by carving and/or grinding bones to create more complex multifaceted, curved shanks and hooks. These implements were still in use at the time of historic contact and complete examples are known from museum collections. . . .They are nearly identical to two-piece hooks from Polynesia illustrated by Buck (1957:332) and Emory et al. (1968: Plate 2 specimens 38–45) (Figure 5). The appearance of this Polynesian composite hook type sometime between AD 300 and 900 is nearly contemporaneous with archaeological evidence for the first use of sewn-plank canoes in the Santa Barbara Channel. The bone pieces used to make these more elaborate hooks are similar but still distinct from bone barbs associated with composite harpoons that also appeared in the Santa Barbara Channel around A.D. 300 (King 1981:357). Not insignificantly, earlier scholars have concluded that the more elaborate two-piece hooks were most effective not in still water but for trolling (Tartaglia 1976:99), which is the way they were employed in Oceania to capture bonito (Anell 1955:152; Reinman 1967:135). In California this type is associated with open-water, mid-channel fishing for pelagic species (Salls 1988:134). Like the tomolo [sewn-plank boat], this type of compound hook is absent from culture areas immediately north (Greenwood 1972; Jones and Ferneau 2002; Jones 2003) and south (Gallegos 2002) of the Chumash/Gabrielino region for the A.D. 300–900 and all other time periods (p. 466).

Jones and Klar's case for Polynesian contact with southern California, in this period of second-wave exploration, centres on the appearance of sewn-plank boat technology at some time in the period AD 300–800. They note that sewn-plank boat technology is common throughout the Pacific but is known from only the Santa Barbara Channel in North America and they note similarities in tools and constructional techniques used in Polynesia and Santa Barbara:

> Tools (including short-handled adzes with shell blades and bone drills or punches) and techniques (construction within a special hut or protective framework of poles and mats) used to manufacture these craft are nearly identical in both areas (p. 477).

They link the appearance of sewn-plank boats with what they describe as punctuated adaptive changes:

> Punctuated adaptive changes in the Santa Barbara Channel during this same era highlighted by a marked increase in exploitation of pelagic fish are the direct results of initial use and increased reliance upon sewn-plank watercraft. Appearance of two-piece bone fishhooks of a type commonly found in Polynesia, following 5,000–6,000 years of stasis in bone hook styles, completes a body of evidence that we feel is substantial enough to offer no reasonable alternative other than cultural diffusion via direct contact (p. 477).

Jones and Klar's case for Polynesian contact with southern California in this period is further supported by linguistic evidence. Indeed they see the linguistic evidence as being as strong as artefactual evidence, arguing, for example, that

> A Chumashan borrowed form /*tomolo' o/ 'sewn-plank canoe' with its four points of consonantal correspondence to the Polynesian source and its historically explicable vowels, is a stronger candidate for borrowing even than kumara 'sweet potato', the only other word generally accepted to have been diffused within the Pacific Basin (though in the opposite direction). We believe that it is beyond the realm of chance that a monomorphemic Chumash word could have four points of exact correspondence with a Polynesian compound of related meaning (p. 477).

Jones and Klar argue that their linguistic findings

> are consistent with a material record that includes two technologies (sewn-plank boats and a particular style of two-piece bone fishhook) that also seem to reflect direct cultural contact between Polynesia and southern California (pp. 476–477).

Jones and Klar specifically argue for transpacific cultural contact with southern California from Polynesia after about AD 300. They support their case for cultural contact from evidence of a timed appearance of new technologies in southern California, offering detailed evidence for transoceanic technological, cultural, artefactual and linguistic diffusion from Polynesia. Their carefully argued case for the appearance of sewn-plank boat technology and a Polynesian style two-piece bone fishhook, used for pelagic fishing in southern California after AD 300, supports our claim for a second wave of Spice Island exploration, based like the first on following the Kuro Shio Current out of the West Pacific Warm Pool to its terminus in southern California. Our paradigm predicts the likelihood both of earlier and of later voyages to southern California via the Kuro Shio Current and predicts that the timings for such voyages would be separated by the severe global cold period between 1000 BC and 400 BC. Such a gap is consistent with the archaeological evidence Jones and Klar present which confirms transoceanic contact and significant cultural diffusion for both of the predicted periods. There is clear archaeological evidence from southern California for transoceanic contact in both periods.

The timing of the introduction by Spice Island mariners of sewn-plank technology in southern California, between AD 400 and AD 800, accords with archaeological evidence of the spread of this technology in coastal Asia in the early centuries AD. Pierre-Yves Manguin notes that the earliest archaeological evidence of a sewn-plank boat in Southeast Asia was discovered by I.H.N. Evans [5] on the bank of the Pontian River, in the State of Pahang, on the east coast of the Malay Peninsula in 1927. Radio-carbon dating yields a date of AD 293 ± 60. This date accords with the dating of ceramics that were found in the wreck by Evans. A second early wreck from Butuan (Mindanao, Philippines) has been dated to AD 320 ± 110 [6]. Pierre-Yves Manguin remarks that both shipwrecks "belong to a shipbuilding tradition which has now been proved to be widespread in Island Southeast Asia, and which may still be observed in remote areas such as Lamalera" (p. 333). The timing for the introduction of sewn-plank boats and two-piece bone fishhooks to southern California after AD 300 also accords with evidence from tradition which, as we have seen, records the migration to Hawaii via Micronesia of a fleet of six canoes led by Irapanga in AD 460 by our chronology (see Chapter 19). Irapanga's migration establishes that the Kuro Shio Current route from the Spice Islands to

Hawaii was still being used at this date. Southern California, we have suggested, was the eastern terminus for that route.

Jones and Klar's map of the distribution of sewn-plank boat construction shows full sewn-plank construction for the Philippines, for the Caroline, Marshall, Gilbert and Ellice Islands of Micronesia, for the New Hebrides, Fiji, the Marquesas and Easter Island and New Zealand but only sewn on washstrakes or gunwhales in Tonga, Samoa, Hawaii, the Society Islands and the Tuamotu. Their map suggests early distribution of the technology of full sewn-plank construction through Micronesia and the loss of the technology in Hawaii following the southern incursions in about AD 1100. It suggests early knowledge of the technology in New Zealand and Fiji.

The archaeological evidence for Polynesian contact with southern California both before 1000 BC and after AD 300 thus fulfils the prediction inherent in our paradigm that Spice Island explorers and/or colonists, in two waves separated in time by the global cold period from 1000 BC to 400 BC, would have discovered and/or colonized Hawaii and reached North America by following the Kuro Shio Current east from Japan as far as the coast of southern California. That both sets of evidence for contact in these two periods are located to southern California confirms a Kuro Shio route and the soundness of our paradigm. The noted similarities of the earlier pre-1000 BC single-piece curved shell Californian fishhooks with Micronesian and Hawaiian equivalents and of the later two-piece bone fishhooks found in southern California after AD 300 with Polynesian and, Atholl Anderson suggests, also Japanese equivalents [7] mark the Kuro Shio route of diffusion in both periods.

6.3 The Polynesian Chicken in America

Recently new evidence for prehistoric Polynesian contact with America has gained worldwide attention. In June 2007 Storey et al. [8] provided evidence for the pre-Columbian presence of two Asian mitochondrial chicken lineages in America. The authors claimed that some 50 chicken bones found at an archaeological site of El Arenal-1 in Chile were of Polynesian origin. The radiocarbon date obtained for the El Arenal chicken bone, in the calibrated age range of AD 1321–1407, dated the presence of the Polynesian chicken in America to before the time of Columbus. These two findings were used to discount the claim that the chicken was introduced to America by the Spaniards. Comparison of the El Arenal bones with 2,000-year-old chicken bones from an archaeological site in Mele Havea in Tonga, and of chicken bones from Fatu-ma-Futi in American Samoa, dating to about the same period as the chickens of El Arenal, showed them to be genetically identical. In addition the authors showed that

> all ancient West Polynesian samples, early samples from Anakena, Easter Island and Kualoa, Hawaii, and the El Arenal sample share a single unique point mutation (a T to C transition) at site 214. One of the modern Araucan feather samples also shares this unique mutation. Three other SNPs (all transitions) at sites 278, 303, and 339 are shared

> by these West Polynesian, early Anakena and Hawaii, and the Chilean bone samples and sequences reported from modern chickens in Southeast Asia, specifically from the Yunnan region of China and Vietnam... Interestingly, samples from archaeological layers dating to later periods at Anakena and from another later prehistoric Easter Island site, Hanga Hahave, did not share these three SNPs. These sequences appear to be more closely related to those of chickens from Island Southeast Asia, specifically from Lombok, the Philippines, and Thailand...This suggests there were two mitochondrial lineages present in prehistoric Polynesian chicken populations (p. 10337).

The clear archaeological evidence cited in the previous section in support of the arrival of Spice Island mariners in southern California, both before 1000 BC and in the period from 300 BC to AD 800, provides a chronological context in which we can at least consider possible arrival times and dispersal routes for the Polynesian chicken in America. (This chronological context of course differs from that provided by a paradigm which sees the settlement of the Pacific following solely from the late west–east settlement of Eastern Polynesia from Western Polynesia.) It opens the possibility that the Polynesian chicken may have been brought to America with either first- or second-wave Spice Island explorers following the Kuro Shio Route to southern California. In this context the term "Polynesian chicken" perhaps more accurately becomes "chicken breeds previously sourced by Spice Islanders from India, Indonesia and Japan".

An early direct route to America from the Spice Islands via the Kuro Shio Current rather than an indirect route via a much later settled Eastern Polynesia implies different sources for the introduced chickens. Long contact of Spice Island traders with India, Japan and probably southern China, for example, suggests that the claim by Gongora et al. [9] for a solely European origin for modern Chilean sequences because they "cluster closely with haplotypes predominantly distributed among European, Indian subcontinental, and Southeast Asian chickens, consistent with a European genetic origin" is dubious when Spice Islanders would have had access to the same sources from which European chickens are derived. Thus the European origin ascribed by Gongora et al. to the Chilean chicken may represent lineages directly sourced by Spice Island traders from India and Southeast Asia and introduced to America before 1000 BC rather than solely derived from Spanish introductions 2,500 years later.

6.4 Consilient Evidence for the Pre-Columbian Introduction of the Chicken to America

The possibility of a very early arrival of the chicken in America is not a new idea, nor is the idea of a Pacific coastal point of introduction and of a Polynesian source for the American chicken. George Carter [10] effectively argues the case for a first-wave introduction. On linguistic grounds he proposes an early arrival for the Polynesian chicken and slow diffusion from New Mexico to Chile paralleling that for maize:

> Birket-Smith (1943:32–33) reduced the names for maize in South America to two great groups: Peruvian and Colombian. The Peruvian group included the old Inca Empire and

> extended into the lowlands to the east—Jivaro, Zaparo, Mosetene and the neighbouring Arawakan tribes. This is strikingly parallel to the distribution of the hualpa names for the chicken. The Colombian maize names had an even wider distribution—to the northwest: northern Peru (Chimu) to Honduras (Lenca), Guatemala (Xinca), and southern Mexico (Chiapanec, Mazatec); to the east: Tupian, Cariban, Tucanoan, and most of the Arawakan. . .Maize is now considered to have been carried from Mexico to South America around 1500 B.C., and the linguistic linkages to southern Mexico thereby gain considerable interest. If maize, spreading after 1500 B.C., has a distribution comparable to that for the chicken, as it does, then there is more reason to think of the diffusion of the chicken as pre-Columbian than as post-Columbian. It is pressing the data rather hard, but if the rate of spread of ideas is taken as about one mile per year, as the Old World model suggests, and if the spread of the chicken from a Pacific coastal point of introduction is assumed, then the distance travelled in South America is about three thousand miles. The indicated time of introduction would be 1500 B.C., about the same time as the introduction of maize. The similarities in distribution and changes in forms of the words are sufficiently parallel to be reinforcing (p. 205).

Though all modern maize cultivars appear to derive from a single line of wild maize which grows today in the Jalisco Valley, not far from Mexico City [11], maize cultivation is ancient, its "characteristic phytoliths", for example, found on a 7,000-year-old tool [12]. Maize appears to have undergone multiple domestications in America. The linguistic pathways (Peruvian and Columbian) which Birket-Smith defined and Carter uses to follow the diffusion of maize southwards from Mexico to Chile after about 1500 BC almost certainly were attached to a specific cultivar or cultivars which may have appeared as new domesticates at this time.

Jones and Klar comment that many archaeologists have noted similarities between the single-piece curved shell fishhooks (which appeared in California before 1000 BC and which resemble those from Micronesia and Hawaii) and single-piece curved shell fishhooks found in Chile. If Carter's suggestion about the "striking parallel" between the diffusion of the hualpa names for the chicken within America and the diffusion of Peruvian and Colombian names for maize is valid, diffusion of these early fishhooks would parallel diffusion rates for both chickens and maize to Chile. This suggests that the Polynesian chicken could have arrived with first-wave Polynesian explorers and diffused along with the single-piece curved shell fishhook from coastal Mexico to Chile by the same pathways as maize.

But, on linguistic grounds, Carter suggests the possibility of multiple introductions of the chicken into America from the Pacific. He proposes that

> the Asiatic chicken was carried into the Pacific through a series of introductions. Asiatic attitudes, customs and even names at times accompanied the bird. The complex of biological, linguistic, and cultural data constitutes the evidence of the Asiatic origin for this immense spread (p. 198).

Further, on the subject of plural introductions, Carter comments:

> We seem rather quickly to assume that we are dealing with single contacts and one transfer of a trait. In the chicken case, we have hints that we may have had plural introductions. Note, for instance, the Japanese name among the Tarahumar and the Hindu names among the Arawak and the Guaymi. Note also that there seem to be two or three Asiatic varieties – naked-necked, rumpless, melanotic, frizzled, silky, peacombed, feather-puffed – in various combinations. Although these could have come in one mixed lot, we have a curious hint

> from Easter Island that varieties of chickens arrived there sequentially, for Metraux (1940: 90) records, "Finally, white fowl – hitherto unknown – began to multiply." Chickens clearly arrived at this outpost in the Pacific in a sequence, and the varietal differences record this sequence (p. 214).

The genetic evidence of Storey et al. demonstrates an archaeological sequence between early and late sites on Easter Island that confirms Metraux's historical information and Carter's suggestion of plural introductions. Carter makes the point that introductions are most likely to have occurred with "a pattern of intermittent spurts and delays" because the introduction of the chicken involved the transference not of a food animal but of a cultural complex in which often the chicken was not eaten at all.

Because cultural complexes associated with chicken introductions are likely to be linked to the timings of introductions, to the ultimate origins of the chicken lineages involved and to diffusion paths within America, study of associated cultural complexes invites attention. Here the work of Carl Johannessen is particularly relevant.

6.5 The Asiatic Melanotic Chicken

The Asiatic melanotic chicken (black-boned, black-meated and black-skinned) is found amongst Maya-speaking groups in North America, Guatemala and Mesoamerica and as far south as the Arauco Peninsula in Chile as well as throughout the Pacific. It is associated with two different cultural complexes, that of cockfighting noted by Carter and that of shamanic and medicinal use, explored in 1982 by Carl Johannessen and Chen Fogg [13]. Johannessen and Fogg show that in the practice of traditional Chinese medicine both in southern China and amongst the K'ekchi Indians of Guatemala, the black-boned, black-meated chicken (BB-BMC) is used to heal a variety of psychic and physical conditions in ways that are astonishingly similar or identical to uses recorded from ancient Chinese traditional medicine and known also from modern southern Chinese traditional medical practice. In both traditional Chinese and K'ekchi practice, for example, for asthma and pulmonary problems "the live BB-BMC is cut lengthwise (sagitally), and the cut sides of the uncleaned, quivering, halves are bound to the soles of the feet. The chicken is left there until cold, or for two hours, or for the day depending upon the curer" (p. 81). In both southern China and in Guatemala the melanotic chicken is used to cure pulmonary problems, evil-eye, fever, pregnancy problems, and, in the form of soup, to give strength to the post-partum, lactating mother. Eating melanotic chickens as ordinary food is avoided "out of respect for its wonderful, protective and curative powers" (p. 79).

In a second paper [14], Johannessen studied the diffusion of this shamanic/medical complex. He visited Hawaii, Samoa, Tahiti, Easter Island, southern Chile, the Altiplano and Yungas of Bolivia, Peru, Ecuador, Colombia, Costa Rica and Guatemala. Because Hamp and Olson, linguists studying Mayan languages, had discovered, respectively, that the Mapuche of southern Chile and the

Chipaya of the Bolivian Altiplano speak languages with affinities to proto-Maya, Johannessen included these two areas in his itinerary "to test the hypothesis that speakers of languages derived from Maya have more homologous uses for the melanotic chickens than their non-Mayan neighbours". Johannessen studied the geographical distribution of American tribes in North and South America that use the melanotic chicken to heal a variety of psychic and physical conditions in ways comparable with the K'ekchi of Guatemala and with ancient and modern southern Chinese traditional practice.

His conclusions establish a clear pattern of diffusion in America for the Chinese medical complex associated with the melanotic chicken:

> The Chinese literature and modern practice describe the ethnomedical treatments for specific maladies through the use of BB-BMC. Among modern Maya of Mesoamerica (Chorti, K'ekchi, Chol) the same infirmities are cured with effectively the same application of BB-BMC feathers, blood, organs, meat, halves as poultices, etc. Six to seven hundred kilometres to the north of the Chol, the Huastecas (with a Maya language) utilize a large portion of the Mayan-Chinese ritual. The Chipaya 4000 km to the south are the most Maya-like of the South American groups I interviewed. Since they are said to have a proto-Maya derived language, their use of the BB-BMC fits a diffusion model. The additional filtering provided by another 2000 km has removed most Maya features from the ethnomedical system of the Mapuches (or Araucanians) of southern Chile, who also speak a proto-Maya derived language.
>
> The cultures intervening between the Chipaya, the Maya and the Husastecans do not use the distinctive BB-BMC in the Chinese-Maya medical mode. I postulate a long time period during which the Southern Chinese or at least South Asian arts of folk medicine diffused. They were incorporated into the Maya tradition and maintained best near the zone of primary contact and reduced in intensity the farther Mayan speakers migrated from their culture hearth (p. 433).

As long as a cultural complex associated with a chicken with clear morphological characteristics, such as the melanotic chicken, remains important, the breed and its defining characteristics are likely to be preserved through line breeding. Johannessen's study suggests that Maya speakers clearly played a part in preserving both the morphological characteristics of the Asiatic melanotic chicken in America and in preserving the Chinese shamanistic/medical system that was originally diffused with the chicken and gave the imported chicken value. Johannessen tells us that "one of the few Chinese and Maya-like traits found throughout Polynesia and Andean South America, where and when the melanotic chicken can be obtained" was making a soup from a melanotic chicken and feeding it to a miscarrying woman or a woman exhausted by childbirth or lacking milk [14]. That this practice of making such a healing soup has been recorded in Polynesia suggests the possibility that the Chinese shamanistic/medical system that the Maya speakers still preserve in Mesoamerica may once have been known and practised by Spice Islanders and that it may have been introduced to southern California with a melanotic chicken lineage by either first- or second-wave explorers or traders following the Kuro Shio route. The presence of melanotic chickens in Mexico, which borders southern California (the likely Kuro Shio landfall), and the preservation of the Chinese shamanistic/medical system in nearby Guatemala, close to the Maya speakers' "culture hearth", supports this possibility.

But in the light of the evidence cited by Stephen Jett and considered in Chapter 8, for direct Chinese contact with America (from 1450 BC to 1100 BC and again from about 400 BC to the collapse of the Mayan civilization by about AD 900) [16], a direct Chinese introduction of the melanotic chicken to Mesoamerica seems more likely. This is especially so because its introduction seems to have involved the spread of a Chinese traditional medical system whose diffusion within America, Johannessen shows, follows diffusion routes from a Mayan "culture hearth". Johannessen's association of the melanotic chicken and accompanying traditional Chinese medical system with a Mayan centre suggests that a direct Chinese introduction would have occurred in the period from AD 300 to AD 900. The period of greatest Mayan prosperity and population growth was around AD 600, possibly the time when Mayan influence was most likely to have extended beyond Mesoamerica: in other words the most likely time for the diffusion of the shamanic/medical system associated with the melanotic chicken from a Mayan cultural centre. By AD 900, 90% of the Mayan population had vanished, possibly it has been suggested through the introduction from Asia of diseases for which the Mayans had no immunity [17].

6.6 The Melanotic Chicken and the Cultural Complex of Cockfighting

The remarkable degree of preservation in Mesoamerica down to the present day of an ancient Chinese shamanic/medical system associated with the melanotic chicken, a system only vestigially preserved in Polynesia, strongly supports the likelihood of a direct Chinese introduction to Mesoamerica of both the melanotic chicken and of the associated medical complex. The melanotic chicken may, however, also have been independently introduced to Mesoamerica by either first-wave or second-wave Spice Island explorers or traders, along with a second altogether different accompanying cultural complex, that of cockfighting. Just as the close association of the melanotic chicken with a valued traditional medical system may have played a role in preserving the breed in America, so too the perceived superiority of melanotic chickens as fighting cocks may have played a role in preserving specific melanotic chicken breeding lines in both America and Polynesia. Carter notes that

> Cockfighting is so important, both in the probable homeland of the chicken and among the routes of earliest spread, that numerous authors have suggested this as the original reason for domestication. . .Caesar's note that the British had fowl but did not eat them is part of the evidence that the original spread was not associated with the use of flesh or eggs. The same pattern extends into Polynesia. Cockfighting is very important. Chickens are important for their feathers for headdresses and other featherwork and of only minor significance as a food source (p. 212).

Carter also notes that in cockfighting in Brazil, "the custom is to use blunt natural spurs, as is also the Japanese and Polynesian custom". The similarity between

Japanese and Polynesian use of natural spurs underlines ancient trading and cultural connections and the likelihood of a Kuro Shio route for the introduction of cockfighting to America. For such an introduction is clearly associated with the introduction of melanotic chickens, still bred for the sport in both Polynesia and South America. The breed is found from Mexico to Chile. In America, as in Polynesia, breeding for cockfighting may well have helped preserve specific melanotic lines.

6.7 White Chickens and the Cultural Complex of Sacrifice and Divination

There is a third cultural complex in Polynesia which is associated, not with melanotic chickens with black bones, black flesh and black skin, but with white chickens bred for sacrifice and divination. Carter tells us that "White chickens were used in Hawaii for necromancy – again the Asiatic pattern of the importance of white chickens for ritual" (p. 196). They were similarly used in Tahiti. Possibly the Hawaiian use followed the Tahitian migrations to Hawaii in about AD 1100 (see Chapter 19). In Tahiti the word for chicken, *moa*, doubled becomes *moa moa* meaning sacred. Given the late dates now ascribed to the settlement of Eastern Polynesia, it seems likely that if this chicken lineage reached America, it would probably have been brought from Eastern Polynesia during the warm global climate period we call the Medieval Climatic Optimum. It is clear that Eastern Polynesian voyagers reached America in this period for they brought back the sweet potato (kumara). D.E. Yen dates its arrival in Polynesia at around AD 1000 [18]. This fits well with its introduction to Hawaii by Tahitians in about AD 1100 and with the introduction of the kumara to New Zealand from Tahiti, according to tradition, by Hoaki and Takata (in AD 1200 by our reckoning). There is evidence that white chickens reached Easter Island during this period. Hotu Matua is credited with bringing the chicken to the island. Carter tells us that in Easter Island

> The chicken is involved in numerous ceremonies and sacrifices, and white chickens, especially cocks, were prominent. A white cock was used by sorcerers to cause the death of another person. The most cherished feathers were those of white cocks, which were kept in gourd containers and taken out when headdresses were to be made. The white chicken was also used to conjure with (pp. 197–198).

As noted, Metraux recorded the arrival of the white fowl on Easter Island as the last of a sequence of introductions. Varietal differences recorded this sequence (Carter, p. 214), the white chicken being much later than the black. This sequence fits with the genetic evidence from Easter Island sites for two lineages, the melanotic chicken being associated with the earliest sites. Storey et al. ascribe the two Easter Island lineages that they document to different Asian origins. They connect the melanotic chicken to modern chickens from Southeast Asia, specifically from the Yunnan region of China and Vietnam. A Chinese origin for the melanotic chicken accords with the Chinese shamanic/medical complex still associated with the melanotic chicken and still preserved in China and Mesoamerica. The second mitochondrial chicken lineage Storey et al. define links to modern chickens from Island Southeast Asia, specifically from Lombok, the Philippines and Thailand. Whether this lineage corresponds to the white chicken bred in Polynesia and Asia for sacrifice and divination is unclear. The later arrival of the white chicken in Easter Island and the presence of the second lineage in later sites there suggest this is a possibility.

Carter and Johannessen both argue for an early introduction of the melanotic chicken to America and for slow diffusion of this breed from Mexico to Chile. As we have seen, Carter supports an introduction at about 1500 BC, based on timings for diffusion of the chicken in both Asia and Europe and on comparable rates for the diffusion of maize from Mexico to Chile, beginning in about 1500 BC. Johannessen offers evidence for the patterned diffusion of the Chinese/Maya shamanic/medical system with Maya speakers from a Mayan "culture hearth", the system weakening with distance from the hearth. Carter's suggestion would accord with a first-wave introduction of the chicken before 1000 BC, and Johannessen's, given its connection with a Mayan "culture hearth", with a second-wave introduction. The fact that Mexico borders southern California and that early chicken breeds were more likely to survive in Mexico than in California in historic times, as indeed is seen in the modern survival of melanotic chickens in Mexico, supports a Kuro Shio migration route to America for the melanotic chicken whether brought by Chinese or Spice Island mariners or both. A late Eastern Polynesian introduction of the white chicken to America, as well as to Easter Island, after AD 1000 seems possible. This period would correspond to the active voyaging period during the medieval global warm period that brought the American sweet potato to Eastern Polynesia.

The insights provided by Carter and Johannessen's work illustrate the value of consilient historical and cultural evidence in situations where migration and diffusion pathways cannot easily be tracked through genetics alone, where migration and diffusion pathways may be multiple rather than singular and the timings of introductions unclear. Consilient historical and cultural evidence can provide contexts for interpreting genetic evidence too when morphological characteristics and genetic lineages may not be obviously correlated. Such evidence can allow conflicting interpretations of genetic evidence to be evaluated more readily. For example, as we have suggested, the interpretation by Gongora et al. that Indian and Southeast Asian mitochondrial lineages in the Chilean chicken indicate a late Spanish introduction of the European chicken is challenged by archaeological and historical evidence which supports the possibility that the Chilean chicken could have been sourced either directly or indirectly from India or Southeast Asia or Japan by Spice Island traders and brought to America before 1000 BC. Or that it could have been introduced by Chinese traders along with an ancient medical system and been spread to South America from a Mayan hearth. The possibility that from the 16th century onwards the Chilean chicken could have been interbred with a Spanish-introduced European chicken ultimately derived from the same Indian or Southeast Asian or Japanese or southern Chinese sources complicates the modern geneticist's task of determining migration and diffusion pathways from genetic evidence alone.

Our central paradigm creates a context for interpreting both early and late archaeological evidence for Spice Island contact with southern California and for interpreting evidence for the pre-Columbian introduction or introductions of the chicken to America. The context it provides is strikingly different from that implicit in the accepted paradigm for the prehistoric colonization of the Pacific, which sees settlement following solely from the late west–east colonization of Eastern Polynesian from Western Polynesia.

In summary, at the very least one might argue for one Spice Island first-wave introduction of the melanotic chicken into America, with the breed diffusing slowly from California with maize from Mesoamerica and Spice Island single-piece curved shell fishhooks. This first-wave introduction of the melanotic chicken was probably associated with the cultural complex of cockfighting. Multiple names for the chicken in America, however, as Carter points out, suggest multiple introductions of different chicken breeds: small melanotic chickens from India, rumpless silkies sourced from Japan and white chickens perhaps deriving from Lombok or the Philippines.

Johannessen's research suggests at least one second-wave Chinese introduction to America of the melanotic chicken, associated with a Chinese shamanic/medical complex. Clearly this melanotic chicken was associated with the Maya and diffused from a Mayan "hearth", its spread linked with the spread of Mayan culture and language.

In Chapter 8 we consider the possibility of a continuum of Spice Island contact with America over 2,600 years (minus the 600-year global cold period), associated with the trading of American plants to India. Such a possibility would expand the scope for multiple Spice Island chicken introductions to America beyond anything contemplated in this chapter.

Clearly the history of chicken introductions is complex, as is the history of the diffusion of varying chicken breeds and of cultural complexes associated with them. The continuing importance in America of the melanotic chicken over a long span of time is obvious. It is just possible that line-breeding to enhance prized characteristics may have had sufficient continuity to make it possible for geneticists one day to determine how many first- and second-wave introductions there were, to determine the sources of the melanotic lines and to trace diffusion paths within America.

Placed in a context of possible multiple pre-Columbian Spice Island introductions of the melanotic chicken, we might consider evidence for Spice Island contact with America as extending beyond the Californian archaeological evidence for first- and second-wave Spice Island contact with America. The linguistic and cultural evidence supporting multiple chicken introductions raises the possibility of more extended Spice Island contact with America than the archaeological evidence from California alone suggests.

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Chapter 7
The Horticultural Context

Horticulture, Pottery and Plant and Animal Domestication in the Spice Islands

Abstract This chapter considers a third heritage which, along with the genetic and maritime heritages that Spice Islanders passed on to their Lapita and Polynesian descendants, was vital to the successful colonization of the Pacific. This was the horticultural heritage bequeathed to the Polynesians by their Spice Island ancestors. It involved plant domestication and the manipulated adaptation of domesticated plants to new environments. We argue that the horticultural skills and knowledge that the Polynesians inherited from their Spice Island ancestors, who for thousands of years had been involved in plant domestication in Wallacea, enabled them to successfully translocate essential staple foods to the varying microclimates of the Pacific islands they settled. The Polynesians' past and continuing genetic engineering of some plants and human-assisted adaptation of others enabled them to create an intensive horticulture on Pacific islands able to sustain significant human populations.

Keywords Plant domestication · Hybridization · Lapita pottery

7.1 Plant Domestication in the Spice Islands

In the last four chapters we have focused on the oceanographic background to Spice Island exploration, trading and colonization in the Pacific and Indian Oceans and on the genetic and maritime heritages that Spice Islanders passed on to their Lapita and Polynesian descendants. In this chapter we consider a third heritage that Spice Islanders transmitted to their descendants: a horticultural heritage. This involved skills and knowledge concerned both with plant domestication and with the manipulated adaptation of domesticated plants to new environments. The importance of this third heritage for the colonization of the Pacific is obvious: it enabled the Spice Islanders' descendants to successfully translocate essential staple foods to the varying microclimates of the Pacific islands they settled, and so transform depauperate islands so that they could support significant human populations.

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The horticultural sophistication that the Polynesian peoples acquired from their Spice Island ancestors almost certainly had its origin in the history of the Spice Islands and Wallacea as a major centre for early plant and animal domestication.

It is important to realize that the spices that the Spice Islanders traded were not harvested from wild trees. Over a very long period of time, the qualities of the spices had been genetically enhanced by human-assisted natural selection and by hybridization. The clove trees that produced cloves for trade were very different from the wild clove trees that still grow on the island of Halmahera. The cultivated clove grew on the tiny Halmaherian offshore islands of Tenate, Tidore, Mutir, Machian and Bachian. Through a long process of genetic manipulation, the taste, perfume and the lasting qualities of the harvested clove flowers were intensified, the medicinal qualities of the spice as an antiseptic, an aphrodisiac and local anaesthetic increased. Nurtured for a long period of time on these five islands, these cultivated clove trees lost much of the genetic diversity of the wild forms and became so adapted to the unique microclimates of the five islands that, until the 16th century, they could not be persuaded to grow elsewhere in the region or indeed in the world. The limited genetic diversity of the cultivated clove, of course, greatly enhanced its commercial value. It gave the Spice Islanders a monopoly in both its production and trade.

Two distinct processes are involved in plant domestication. The more usual is human-assisted natural selection, often used to extend the natural planting range of a domesticated plant. We see this technique, for example, used in the human-assisted development of rice cultivars that could be rain-fed on terraced hillsides rather than grown in swamps. We see it too in the development of rice cultivars with a longer ripening time which could exploit the longer hours of sunlight in the temperate zones as opposed to the shorter ripening times in the tropics.

The second process involves hybridization. This involves preventing natural pollination in selected plants, harvesting pollen from other carefully chosen plants and then artificially fertilizing the depollenated plants. Where the plants involved belong to the same variety, the process is simple. But often the most significant improvements occur by crossing varieties that may be so significantly different genetically (for example, having different chromosome counts) that the resultant plants are infertile. They can only, thereafter, be reproduced vegetally, usually through the planting of suckers. The survival and future history of that cultivar becomes entirely dependent thereafter on human intervention. The domestication of the breadfruit and banana in Wallacea provides good examples. Their vegetal mode of reproduction – the cultivated banana, for example, is seedless – is proof that deliberate hybridization was involved in their domestication.

The downside of domestication through hybridization is the loss of genetic diversity and loss of the possibility of future genetic adaptation. There is current concern in Australia, for example, that if an overseas virus affecting bananas reaches Australia, it may cause the end of banana cultivation in the country. Means of further natural selection or human-assisted natural selection to acquire resistance to a virus end when plants can no longer be reproduced by seed. Genetic engineering in a laboratory, an expensive alternative, is now available but, of course, till the late 20th century, this was never a possibility.

Even intensive human-assisted natural selection can lead to the loss of genetic diversity. Though the domesticated clove tree could still reproduce naturally, because it had become so attuned to the unique microclimates of the five tiny islands lying off the west coast of Halmahera in which it was exclusively cultivated, it could not be persuaded to grow elsewhere, as we have noted, till the 16th century. In the 20th century the clove's lack of genetic diversity, the result of prehistoric intense natural selection, has made it vulnerable in places outside the Spice Islands to viruses to which it is not exposed in its homeland. Its ability to acquire resistance has been curtailed by its lack of genetic diversity.

The culture and long-term genetic enhancement of cloves and other spices in the Spice Islands provided a basis for Spice Island local, regional and eventually international trade. This practice of plant domestication, however, was not limited to spices. There is evidence of a long indigenous history of plant and animal domestication in the Spice Islands and in Wallacea. The breadfruit and the coconut, for example, are said to be indigenous to Sulawesi in Wallacea. Their domesticates were spread from there throughout Island Southeast Asia and carried into the Pacific as staple foods. The banana was spread to Africa via the Cinnamon Route and to America conceivably by Spice Island traders following the Kuro Shio Current (see Chapter 8).

Both animal and plant domestication in the Spice Islands and Wallacea represent persistent efforts by generations of individuals over long spans of time. They reveal a persisting cultural attunement to the possibilities of improvements, through what is effectively genetic engineering, to spices grown for trade and to staple foods. And they reveal a cultural attunement to the development and introduction of new plants and animals and to their successful translocation to new environments.

In both tropical Polynesia and New Zealand there is evidence for plant improvements by both human-assisted natural selection and by hybridization. A sacred fern in tropical Polynesia, improved by hybridization, could no longer be spread by seed but had to be divided and planted by hand. A superior fern for eating was taken to the Chatham Islands by an early migrant, Kahu, in about 360 BC (see Chapter 20). Even when crop plants could only be vegetally reproduced, as was the case in New Zealand for most of the varieties of kumara brought there after AD 1200, the horticultural sophistication of the Polynesian descendants of Spice Islanders was still evident. Seventy-seven names for various varieties of kumara are listed by Elsdon Best [1], though he notes that "it is probable that the list contains a number of synonyms or duplicate names". Two varieties, the *puatahoe* and *waiha*, were said to flower (which means that hybridization may still have been possible). All other varieties could only be vegetally reproduced. In tropical Polynesia most of the varieties brought to New Zealand bloomed and annually produced seed and could be improved by hybridization. In New Zealand where, certainly after the beginning of the Little Ice Age in about AD 1400, it was too cold for most kumara plants to flower, improvement through human-assisted natural selection of tubers was the only means of improving adaptation to New Zealand conditions. The

Eastern Polynesians who introduced the kumara to New Zealand may have recognized that bringing a significant selection of the varieties grown in tropical Polynesia offered the best chance of finding ones that would allow for differential adaptation to varying locations and microclimates within New Zealand. These early Polynesian varieties were very different from those grown in New Zealand today. Many were only the size of a finger and were as long and thin as a finger, though, according to Polack whom Best quotes, they were "extremely farinaceous and nutritious" (p.114). The European sweet potato, introduced by an American whaler in 1819, which can weigh several pounds, is the variety now grown in New Zealand.

The Lapita-age introduction of the Japanese taro to New Zealand, discussed in Chapter 3, involved the introduction of a variety better adapted to the higher latitudes and colder conditions of New Zealand than the tropical taro cultivars that were introduced into Eastern Polynesia. These varietal choices, though widely separated in time, are evidence for a complex horticultural awareness of factors making for the successful translocation of a plant to distant colonies with varying climatic and growing conditions.

Thousands of years after the Lapita migrations, we find in the prehistoric Polynesian descendants of the Spice Islanders a persisting cultural attunement to factors governing the successful translocation of plants into new environments, of the need to continually adapt plants to changing soil conditions, climates and latitudes. It is an interesting fact that Maori who, we believe, for over 2,000 years in New Zealand lived a settled hunter/gatherer rather than a horticulturally based life nevertheless had different names for the male and female forms of some trees, in which both sexual reproductive means did not exist on the one tree. This naming points to their cultural awareness of the possibilities of hybridization, a more complex process than the more common technique of assisted natural selection. Probably from the earliest times in New Zealand, horticultural knowledge handed down from the first Spice Island colonists was used to improve forest staples such as fern and berries.

Human-assisted natural selection and artificial hybridization, then, both involve persistent efforts over many generations, for it is a continuous, ongoing process. They also involve a culturally transmitted ability to recognize and breed for characteristics such as taste, vigour and disease resistance, and, in the case of cloves as we have seen, for such characteristics as intense and long-lasting perfume, taste and optimal medicinal properties.

Generations of cumulative horticultural experiment and transformation lie behind the Spice Islanders' cultivation and exploitation of the spices they grew for trade. They also underpin the Lapita and Polynesian peoples' successful colonization of the Pacific and the translocation there of the plant and animal domesticates that made survival on remote tropical islands possible. For the remoteness and isolation of Pacific islands restrict natural means of seed dispersal and inevitably result in low plant diversity. The Polynesians' translocations of plants, their past and continuing genetic engineering of some plants and human-assisted adaptation of others, enabled them to create an intensive horticulture on Pacific islands that was able to sustain remarkably large human populations. The adaptations required cannot have been trivial. Plants from the Spice Islands and Wallacea had to be attuned to microclimates very different from those of the Spice Islands and, within the Pacific, different from island to island.

Mike Hendy has established that a differential mutation of the Japanese taro occurred (possibly, we suggest, in New Zealand) between 2,000 and 3,000 years ago. The early colonists' recognition of the value of the resulting cultivar and the vegetative reproduction of this mutated variety over millennia explain its survival to modern times.

The successful translocation of domesticated plants indigenous to the Spice Islands and Wallacea, which marks the Polynesians' paths across the Pacific, supports our argument for their long genetic, maritime and horticultural history in a Spice Island homeland. It supports our claim for the evolution in the Spice Islands of traditional knowledge and skills, both maritime and horticultural that, passed on to their descendants, enabled the Lapita and Polynesian peoples to successfully settle every significant island in the Pacific. Patrick Kirch [2] lists 28 species of crop plants successfully translocated by the Lapita peoples to Pacific islands. Indeed, Kirch claims that "the Lapita horticultural complex encompassed all of the essential crops and agronomic strategies that laid the foundation for the more elaborate horticultural and agricultural economies of later Oceanic societies" (p. 217).

In Wallacea translocating plants from one biological zone to another was possible because the Wallaceans possessed the maritime skills needed to cross Wallace's Line, which separated the two biological zones, Asian and Pacific. The reason that many early plant domestications can be attributed to Wallacea is that its peoples possessed the needed combination of maritime and horticultural skills. That domestication involved more than shipping plants across the ocean trench can be established from the examples of breadfruit and bananas, whose domestication involved complex chromosome manipulations leaving the plants sterile. Similarly a combination of maritime and horticultural skills would have been needed also for the Spice Islanders' conceivable role in trading American indigenous plants to India, discussed in Chapter 8. Not only were two transoceanic crossings needed for such trade but horticultural skill and knowledge were needed for choosing varieties most likely to survive translocation.

The genetic manipulations needed for plant domestication involve breeding for size and taste and vigour. The primitive precursors of most of the foods we eat would be unrecognizable to most people. The distressing acrid taste of a tiny rootstock cherry and a 2-in.-long corn cob with only a few kernels, for example, would seem unpromising prospects for generating future food crops. Breeding for growing characteristics such as cold resistance or heat resistance, drought resistance, disease resistance and cropping capacity have been engineered in many cases over thousands of years: engineered through human-assisted hybridization or human-assisted natural selection or both. Where, as is often the case, the evolved plant has lost vigour, it has to be grafted back onto the primitive form from which it descended, the primitive rootstock supplying the vigour lost in the course of its human-directed evolution. In nature, of course, weaker forms lacking vigour or the capacity for sexual reproduction or genetic versatility would die out. Plants rendered weaker or sterile though human manipulations can only survive through continual human intervention. The survival of plants like the banana and breadfruit has depended on thousands of years of just such continuous intervention.

Plant domestication is a worldwide phenomenon but there are varying degrees of sophistication involved in different parts of the world and amongst different peoples. The level of Spice Island sophistication, domesticating experience and horticultural awareness appear to have been unusually high. Spice Islanders, as we have demonstrated, had a correspondingly high degree of maritime sophistication, experience and awareness. We argue that the combination of skills in these two areas made possible their role as explorers and colonizers of the Pacific. It also made possible their role as transoceanic horticultural traders, trading spices internationally for possibly 6,000 years and, we shall suggest in the next chapter, conceivably trading American plants to India through two oceans over a period of 2,600 years.

7.2 Lapita Pottery

The discovery of pottery at Lapita in New Caledonia in 1952 gave the Lapita people their name. The importance of pottery in their culture fits well with the prehistory we propose for the Lapita peoples as descendants of Spice Island maritime spice traders. Pottery and trading go hand in hand. In the Mediterranean, marine archaeologists discover ancient shipwrecks by the outline formed on the ocean floor by hundreds of clay amphorae that the ships once carried as cargo, containers for the olive oil and wine being traded. Ancient ceramic workshops are found near Mediterranean harbours. The huge storage jars found in the palace of Knossos in Crete once stored wine and oil; some may represent tribute from vassal states. The Lapita ceramic tradition accords with the Spice Islanders' role as spice traders. If precious spices were transported over long distances in outriggers lying low enough in the water to be paddled, they would have been continuously exposed to wave splash and spindrift. Pottery jars would have been needed for their safe transport. The elaborately decorated early Lapita pots would have been especially appropriate for luxury trades involving spices and plumes.

Wooden and bamboo storage containers and gourds were probably used for very early local and regional sago, spice and plume trading. But these containers may well have proved inadequate for long-distance trading and international spice and plume trading. By 6,000 years ago when there is evidence of long-distance and international coastal trading from the region, we might expect to find pottery associated with the luxury plume and spice trade. Swadling draws attention to incised and applique pottery from Dudumunir cave in Irian Jaya, comparable to the 5,000 BP pottery in Timor. She implies that it is possible that the Dudumunir pottery was made for the luxury plume trade, though it predates decorated Lapita pottery by 1,500 years. Earlier undecorated pottery may have preceded this later decorated ware. Possibly, ancient trading links with Japan 6,000–7,000 years ago, made possible by the increased warmth of the West Pacific Warm Pool, may have led to the Spice Islanders' acquisition of the technology of pottery making or to their acquisition of pots for their spices and plumes through trade with Japan. The finding of Jomon pottery in Vanuatu dated to 5,000 BP may be relevant in such a connection [3].

The decline of the pottery tradition in Island Melanesia and most of Western Polynesia, from decorated to plain pottery, may reflect the loss by these colonists of the spice and plume trades: luxury trades for which the decorated pots may originally have been made.

If pottery and trading go hand in hand, so do pottery and horticulture. Lapita jars, and especially those with narrow necks, have been associated with the storage of sago. Kirch [4], for example, suggests that the undecorated large globular Lapita jars "with narrow necks" were used to hold "flour" derived from the pith of sago (*Metroxylon*) palms. When kept dry, sago flour will keep for extended periods, and Kirch argues that this food may have been essential to tropical colonizing groups while their horticultural systems were being established. Sago flour may have proved as useful for crews on long-distance trading voyages or migrations.

The absence of a pottery tradition in Eastern Polynesia suggests that without trade requiring pottery, and without reliance on sago flour as a carbohydrate staple needing storage, it was simpler to use gourds or to manufacture wooden storage vessels.

The presence of a vestigial clay tradition in New Zealand, possibly associated with the Lapita-age origins of its first settlers, is discussed in Chapter 16.

7.3 The Lapita Migrations

The immediate causes of the Lapita migrations that may have followed the catastrophic Mount Witori eruption in New Britain (c. 3,600 BP) may never be known. It is easy to suggest possibilities. Earthquakes and tsunamis, accompanying the eruption, might have devastated the Bismarcks, the Solomons, the north coast of New Guinea, northern and possibly southern Halmahera and islands in the Moluccan archipelago, with significant loss of life. With crops damaged, trading canoes destroyed, and cropland inundated, Spice Islanders might have become vulnerable to the attacks of tribes from outside the affected areas who seized the chance to wrest spice-producing islands from them. Alternatively we can speculate that there might have been an opportunistic response by the Spice Islanders themselves to the sudden de-peopling of the Bismarcks through the eruption. They may have seized the opportunity to acquire a rich trading resource, that of Talisean obsidian, and to take over significant land areas temporarily rendered infertile and vacated. The two possibilities may have conjoined. Whatever the causes for the Lapita migrations to Near Oceania, the size of the Lapita sites – especially the 80-ha size of the earliest known site at Talepakemalai in the Bismarck archipelago – suggests a remarkable, large-scale response. The degree of organization involved and the cultural uniformity and prosperity of the new sites are striking. Kirch [5] speaks of the "sudden appearance of sites ranging from the Mussau islands and Ambitle, to New Ireland, to the Arewa group off the southern coast of New Britain, and on to Nissan and Buka in the northern Solomons". He notes that

> Several characteristics render these sites wholly different from anything preceding them in Near Oceania. First they were good-sized settlements. . .situated on coastal beach terraces or built out over the shallow lagoons as clusters of stilt-houses. Second, their occupants made, traded, and used large quantities of earthenware ceramics, of both plain and decorated varieties. Third, the economic base had expanded from that of the preceding phase in Near Oceania, utilizing all of the tree crops that had been domesticated in this region, but also including pigs, dogs and chickens. Fishing strategies were sophisticated, and they employed a variety of fishhooks, including trolling lures for taking tuna and other pelagic fish on the open ocean. . .The Lapita people were seafarers, venturing beyond coastal waters to move substantial quantities of pottery, obsidian, chert, oven stones, and other materials between their communities, frequently over hundreds of kilometres. Their material culture exhibits a greater range of tools, implements, and ornaments than any earlier sites in Near Oceania.

Most remarkable perhaps is the scale and the speed with which the so-called Lapita peoples colonized the Bismarcks and then, probably in the space of a few hundred years, went on from the establishment of a host of successful colonies in the Bismarcks to explore beyond Near Oceania and move out into the Island Melanesia and Western Polynesia. There they established colonies, possibly with significant founder populations, in a southeastward flowing arc of islands reaching to Vanuatu and New Caledonia.

Some prehistorians believe the initial thrust of the Lapita migrations ended at this point with a 600-year hiatus (Anderson et al. [6] suggest a 1,500-year gap), before the west–east colonization of the Pacific began from the Lapita colonies of Western Polynesia. Such a hiatus, we have stressed, would include the severe global cold period beginning in about 1000 BC, lasting till about 150 BC in Europe but possibly ending around 400 BC in the southern hemisphere.

7.4 A Translocated Landscape

The size of the founder population needed to create the 80-ha site at Talepakemalai and of the founder populations needed to populate the primary Lapita-age colonizing targets of Madagascar, New Zealand and Hawaii as well as the later range of colonies in Island Melanesia and Western Polynesia suggests that the Lapita peoples were skilled migrants, that they both understood and could provide the basic requirements for successful colonization. Kirch [7] ascribes the phrase "man's transported landscape" to ethnobotanist Edgar Anderson who used it, in Kirch's words "to refer to the ensemble of crops, weeds, animals and vermin and other biota that accompany all human populations but especially agricultural people as they expand into new territories" (p. 109). Kirch extends the suggestion of the phrase, commenting, "The transported landscapes of the Lapita peoples were a fundamental part of what made them – and in due time their descendants – able to settle virtually every speck of habitable land in the Pacific Ocean."

We suggest extending the concept further and speaking not just of the homeland landscapes being transported but "translocated", a term used by Tim Flannery in an article on the zoo-geography of New Ireland [8]. The translocation of the homeland landscape is not simply a matter of introducing domesticated plants and animals to a new colony. It involves, more comprehensively, the translocation of cultural technologies and skills and of the social structures that preserve them and enable the colonists to assist with the adaptation and survival of the introduced plants and animals on which they will depend for survival. It was by carrying with them what we would describe metaphorically as an "ark of resources", in this extended sense, that the Spice Island colonists could establish the horticultural and animal husbandry and fishing skills that their culture was built on. By including in each migration experts able to practise and teach traditional skills and technologies from all areas, they guaranteed not just the perpetuation of their homeland societies in a new environment but also secured the possibility of having the future human resources to accomplish the adaptations and evolutions needed to meet the new demands and challenges and possibilities of that new environment.

Perhaps of central importance in the ark of resources that Spice Island colonists carried into the Pacific was the "ark" itself, the maritime technologies they had evolved in the Spice Islands over tens of thousands of years. They had skills which enabled them to build canoes – not crude dug-outs as the name suggests – though indeed they were crafted using only stone axes and were held together with plaited vines – but ocean-going vessels. They had astronomical knowledge that enabled them to navigate at sea, to follow star paths, and they could read winds and waves and currents. It is possible that Lapita-age Spice Island colonists travelled in Halmaherian double-masted, double-outriggers, and they probably travelled in a fleet of six or seven canoes. (The earliest oral migration traditions mentioned in Chapter 5 describe such fleets.) Spice Island technologies provided a sophisticated base for the evolution over time of the Polynesian canoes that Captain Cook encountered. Cook estimated that these could sail at least a third faster than *The Endeavour* and out-manoeuvre his ship. Surprisingly, the largest Polynesian double-canoes of Cook's era were indeed larger than *The Endeavour*. Where it measured 106 ft in length and was, at its widest, 29 ft 3 in., some of the larger Polynesian double canoes measured up to 108 ft and were 50 ft wide. They had nothing like the carrying capacity of *The Endeavour* and, sitting low in the water, were unable to cope with the storminess of the higher latitudes, but they were faster and, in the world for which they were crafted, marvellously adapted. Some could achieve 22 knots in good conditions [9]. In the 20th century Gustav Erikson's grain ships averaged less than 6 knots a day (Graham Peacock, deepwaterman, personal communication).

The "ark" – the maritime technologies – and the resources they could translocate to a new colony were vital to successful colonization. The later Eastern Polynesian double-canoe could possibly carry 200 people. A large Halmaherian double-outrigger may have carried only 50. Tradition suggests fleets of canoes were used to ensure a significant founder population. It is empirically clear from the success of the Spice Island Lapita-age colonies that the colonists understood the need for a significant founder population and sought to include colonists who possessed and could teach and hand on all the traditional skills on which their culture depended.

The critical size and composition of a founder population for a successful colony undoubtedly depended on its having a representative cross-section of the homeland society – a tenet Edward Gibbon Wakefield put into practice in the 19th century when founding the colony of South Australia and colonies in Wellington and Christchurch in New Zealand. A representative cross-section of society is a vital part of the colonists' ark of resources – partly to represent, in microcosm, the socio-political structure of the homeland society, evolved by the migrating peoples over time and basic both psychologically and practically to physical and cultural survival.

In a Lapita and Polynesian context, the microcosm needed to include teachers and practitioners for all the society's technologies from fishing to weaving, from boat-building to navigation, from medicine and shamanism to the teaching of cultural history and traditions which embody survival strategies, cultural prerogatives and spiritual knowledge and practices. Castaways can adapt and survive in a new land and perhaps slowly create a new society. But cultural translocation, and the significantly sized founder populations this implies, not only ensures long-term survival but also gives an onward impetus for further expansion and a surer base for the cultural and material innovation and adaptation that underpin such expansion. It is, then, not surprising that the earliest traditional accounts of migrations, such as the whare wananga accounts S. Percy Smith published, speak of migration fleets of six or seven canoes [10]. Indeed, their ensuring significant founder populations might be seen as implicit evidence that the Lapita peoples were skilled migrants. And it is not surprising to find that in Polynesian societies, involved throughout their histories with migration, fleets of migrating canoes occur not just down to the time of Kahukura in about AD 1230, as we describe in Chapter 18, but down to the time of the *Heke*, the last migration fleet, which reached New Zealand about 600 years ago.

The speed and success with which the Lapita colonies were established in the Bismarcks, Madagascar, New Zealand, Hawaii, Island Melanesia and Western Polynesia imply significant founding populations in each. Possibly all these founding populations were drawn directly from the Spice Islands, possibly later they also included experienced colonists from established colonies in the Bismarcks and Solomons. Whatever their immediate origin, there seems little doubt that large numbers of colonists were involved and that a remarkable degree of co-ordinated organization underlay the fast expansion in first and second waves of Spice Island migrations. It is a matter of conjecture whether the setting up of inter-island trading regions as a means of ensuring self-sufficiency and independence for the colonies was a matter of deliberate organization or a serendipitous development due to a degree of isolation enforced on the new colonists by the advent of a cold climatic period in c. 1000 BC. Certainly there is evidence of trading links and technological interchange between the Spice Island homeland region and Eastern Polynesia up to the time of Tangiia (about AD 1294 by the chronology we construct in Chapter 19). There is evidence too of trading links and technological exchange between the colonies of Western Polynesia and Micronesia up to the time of European contact, a span of over 3,000 years, though climatic changes may have made such contacts intermittent. Captain Cook, for example, noted design improvements in Polynesian canoes between his first and second visits to Polynesia, improvements due to Polynesian adoption of a recent Micronesian design advance [11].

7.5 A Readiness to Seize Opportunities

The Spice Islanders' readiness to seize opportunities is suggested by possible rapid colonization of lands unpeopled by the Mount Witori eruption, by their rapid movement after this into Remote Oceania and by their colonizations of Madagascar and New Zealand. This readiness to seize opportunities is reflected in their descendants' successful later colonization of the Pacific and underlies the cumulative cultural experience, recorded in their oral traditions, of repeated successful expansions. Their readiness to seize opportunities is reflected in diverse ways, in recognizing, often two or three days in advance, the right weather patterns, the optimal combination of winds and current and swell for launching a migrating fleet; in recognizing the potential of new technologies and food crops they encountered and adopting them rapidly; in instantly exploiting a momentary advantage in battle. The readiness to seize opportunities, characteristic of both the Lapita and Polynesian cultures, may help to explain the success of the Spice Islanders and their Polynesian descendants as explorers and colonists.

It is known that the Lapita people possessed a double genetic advantage in resisting malaria (in contrast with coastal New Guineans who carried only the alpha Thalassemia gene). Perhaps their population growth rate was greater than that of their Melanesian neighbours and the urge to establish colonies to relieve population pressures was therefore greater. Perhaps, added to this, as has often been commented, their cultural system of primogenitural inheritance and their cultural emphasis on founder status also drove migration, with younger sons eager to break away from the tribe to acquire land and status for their descendants. But basic to Spice Island and Polynesian explorations and colonizations of the Pacific, we would argue, was the genetic and cultural evolution over thousands of years as long-distance maritime traders and possibly also as post-flood colonizers in their own region. The evolution of cold-resistant and famine-resistant genes was crucial. Almost as important must have been their millennia of horticultural and maritime experience, their mastery of ocean currents and their awareness of the predictable patterns of these currents, their knowledge of astronomy and of the star paths needed also to guide them in a trackless ocean, their capacity to translocate and adapt plants and animals to new environments. They possessed an intensely practical culture, organized to ensure that skills and knowledge were carefully transmitted from generation to generation. But, as their traditions show, it was a culture that also appreciated individuality, fostered courage and daring, encouraged individuals and tribes to turn their backs on disasters and to seize new opportunities as they arose.

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Chapter 8
Transoceanic Trading in Two Oceans

Could Spice Islanders Have Traded American Plants to India?

Abstract This chapter explores the possibility that Spice Island mariners may have been responsible for trading American plants to India over millennia. That such trade existed is clear from the research of John Sorenson and Carl Johannessen. Using a combination of botanical and archaeological evidence, they establish that over a span of 2,600 years from 1600 BC to AD 1000 at least 40 American plants were introduced to India. We argue that Spice Islanders had the motive, means and opportunity to handle such trade: the needed maritime and horticultural skills, a long history of transoceanic exploration, trading and migration, a long history of plant domestication in Wallacea and mastery of transoceanic voyaging in two oceans. The implication of conceivable Spice Island involvement is a frequency of transpacific voyages far in excess of that implied by the archaeological evidence from California for Spice Island contact with America.

Keywords Chinese voyaging to America · American plants to India · Old World plants to America · Transoceanic trading

8.1 Introduction

We have studied the long maritime history and the long horticultural history of the Spice Islanders and suggested the relevance of both for their colonization of the Pacific. In this chapter we consider the possibility that this double background may have been valuable and enabling in another way altogether: that it may have equipped Spice Islanders to develop a rare plant trade, accessing food and medicinal plants in America and trading them to India. That such a plant trade existed is clear from the recent research of John Sorenson and Carl Johannessen [1]. Using a combination of botanical and archaeological evidence, they establish that over a span of 2,600 years from 1600 BC to about AD 1000 at least 40 American plants were introduced to India. Recognition of the distance and time scale involved raises the question as to which traders could have been responsible for this trade. Sorenson and Johannessen neither raise nor answer this question.

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That the Kuro Shio Current was the ocean route followed to America by Chinese mariners as well as Spice Island explorers seems clear from the initial Chinese impact on Mesoamerica and the spread of influence southwards to coastal Peru and Ecuador. American diffusionists claim that there is archaeological and cultural evidence for persistent Chinese contact with America from 1450 BC to AD 900. The one period in this span in which there appears to have been no Chinese contact is a 600-year period which corresponds to the global cold period beginning in about 1000 BC [2]. In contrast, the archaeological evidence for Polynesian contact with America that we considered in Chapter 6 minimally implies only three transoceanic voyages – one first-wave voyage before 1000 BC and possibly two second-wave voyages after AD 300. This sharp difference in voyaging frequency suggests that Chinese mariners were far more likely to have traded American plants to India than Spice Islanders.

However, if the influence that Chinese traders appear to have had on the high civilizations of America is compared with the influence of Spice Island mariners on southern Californian coastal communities, this conclusion can be challenged. It is conceivable that Chinese traders may have been responsible for the rare plant trade that Sorenson and Johannessen document. There is certainly a significant body of evidence for a long continuity in Chinese contact with America, though because we are dealing with the long-standing diffusionist/anti-diffusionist debate, even the claim for a significant continuing prehistoric contact between China and America is controversial. But it is clear too that the skills involved in accessing suitable plants in America to match to appropriate environments in India presuppose a high degree of horticultural experience and perhaps a long contact with India. Such skills suggest a level of horticultural expertise more likely to be found amongst Spice Island horticulturalists and traders than amongst Chinese traders who seem primarily to have influenced urban architecture and complex social structures and contributed specific artistic styles and decorative techniques.

8.2 Chinese Contact with America

Even a brief consideration of the diffusionist literature draws attention to the differences between Chinese and Spice Island traders as likely candidates for trading American plants to India. Stephen Jett [3] provides a clear and concise discussion of the diffusionist case in a discussion that ranges from broad-scale comparisons of contemporary Chinese and American civilizations to detailed comparisons of shared artistic motifs. He ranges from descriptions of urban architectural similarities to the discussion of the American adoption of Chinese place names. Just a few examples from Jett's writing can suggest the nature and extent of Chinese influence in the Americas which he is concerned to demonstrate and the kind of sophisticated interaction between two cultural worlds that these examples imply. Jett's examples highlight the differences between Chinese contact with the high civilizations of America and Spice Island contact with the Chumash and Gabrielino of coastal California described in the last chapter.

Though there is a considerable body of academic literature favouring Chinese transoceanic contact with America, as we have commented, there also seems to be an unbridgeable gulf in America between diffusionists and anti-diffusionists. While anti-diffusionists argue for independent evolution of the major American civilizations, diffusionists argue that through repeated Chinese contact with America over an extended period of time, Chinese technologies, cultural motifs and artistic styles had a major shaping effect on the evolution of the high cultures of Mesoamerica, Peru and Ecuador. Because this contact is inferred, that is, it is based on scholars' perceptions of Chinese cultural and technological influence, it is challenged by anti-diffusionists as being less than adequately robust. And yet, as Jett shows, much of the evidence that has been gathered in favour of repeated Chinese contact and of persistent cultural and artistic influence is clearly dated, specific and striking.

Jett attributes the first significant Chinese contact with America to the Shang dynasty and compares it with the Olmec:

> the first Bronze Age civilization in the Yellow River valley in northern China, developed upon a Lungshan Neolithic base during the eighteenth century BC or earlier. It was a hierarchical civilization with a capital and administrative and religious centers whose buildings were often built on earth platforms with a north-south orientation. The Shang possessed ideographic writing, produced richly decorated ritual bronze vessels, knew gold and silver, valued jade, and buried their elite with retainers and grave furniture in subterranean tombs. They practiced water control, had long-distance trade networks, made war with chariots, and controlled a large area.
>
> On the Gulf of Mexico, in Veracruz and Tabasco, lay the heartland of what has been called America's first civilization, the Olmec. It possessed a hierarchy of leaders, constructed complex north-south-oriented ceremonial centers on artificial earth platforms, erected large earthen mounds, produced monumental stone sculptures and superb lapidary work in jade and other stones, practiced water control, had long-distance trade and widespread influence, and apparently used systems of enumeration and ideographic writing. Its calibrated dates are about 1450–650 BC (p. 607).

Summarizing a considerable diffusionist literature linking Shang and Olmec, Jett draws attention, for example, to a shared feline cult:

> Much has been made of a "feline cult" in comparing archaic China (tiger) with Olmec and later Mesoamerica (jaguar). Emphasis on animals of such power and hunting prowess is not surprising, but certain specific shared aspects of feline representation, such as frequent absence of a lower jaw, are more arbitrary. Meggers (1975; 14, 17) points out that felines appear to have been earth gods in both regions. Additional themes common to the Shang and the Olmec are felines protecting (devouring?) children. . .which is a variant of the alter-ego motif, and monster-mask headgear. . .Birds or bird monsters are iconographically significant in both areas. The plumed (?) or winged serpent (Quetzalcoatl) and the four-legged fire serpent are said by Coe to have been two of the principal Olmec deities, and serpents and dragons are abundantly depicted in Shang China. Other similarities have been pointed out, but perhaps the ones most deserving of detailed examination here are those relating to the use of green stones, particularly jade (pp. 607–608).

Jett notes that, while on the whole Shang and Olmec jade objects are quite distinct, common to both areas

> are rounded jade celts, often interred with corpses. Celts sometimes carried faces engraved or painted in red. In China, ritual objects such as slender *yuan kuei* seem to have evolved

> from celts; artifacts of similar form and size occur in buried offerings at La Venta. . ..Other classes of jade objects common to Shang and Olmec include beads, bird and animal plaques, pendants, and figurines. . .In Shang China and later. . .shell, turquoise, or jade was put in corpses' mouths, and at some point in history rice was. At least in Classic Maya times, jade and maize were put in corpses' mouths; funerary jades in both areas were sometimes coated with or associated with cinnabar [a heavy, reddish mercuric sulfide, HgS, that is the principal ore of mercury]. Jade seems to have been used medicinally in both areas (pp. 609–610).

While some evidence for archaeological similarities might be dismissed as instances of parallel evolution, the preservation of Chinese place names in America is harder to explain:

> It may be noted that the layout of Teotihuacan is reminiscent of that of the Chinese city in emphasizing an interrupted north-south axial street and a rough gridiron layout and in being composed largely of walled household compounds with courtyards. Unlike the Chinese city, Teotihuacan lacked an encompassing wall . . .Relevant to the finds of the Chan Chan area, Loayza. . .listed 95 Peruvian place names that have meaning in Chinese but not in local languages, plus 130 Peruvian place names corresponding to Chinese place names. These are concentrated particularly from Lima northward. Among additional traits shared by China and Peru, the following are of especial interest: metal disks or coins put into cadavers' mouths, tally strings (quipus), suspension bridges, great walls. . .and elaborate agricultural terraces (p. 623).

Even these few examples suggest a significant difference between the nature of Chinese involvement and influence and that implicit in the archaeological evidence for Polynesian contact that we considered in Chapter 6. Chinese traders represented sophisticated urban Chinese cultures. Their influence appears to have been predominantly artistic, cultural and technological and to have influenced developed American urban cultures. Evidence from southern California for Spice Island contact and influence relates to boat-building and fishing and affected coastal maritime and fishing communities. The Spice Island introduction of the melanotic chicken was related to cock-fighting, the Chinese introduction of the melanotic chicken was associated with a shamanic/medical complex that, as we have seen, spread along with the chicken from a Mayan hearth. We suggest that although there is a very considerable range of evidence for continued Chinese contact with America over 2,500 years (minus the 600-year global cold period), the sharp difference in the backgrounds, and in the kind of contacts, interests and influence of Chinese and Spice Island traders, weights the likelihood that Spice Islanders pursued the rare plant trade that Sorenson and Johannessen document.

The different capacity of their watercraft perhaps highlights the differences in Chinese and Spice Island trading emphasis and potential. Carrying possibly heavy or fragile art objects from China to America in the second-wave period – elaborate lacquer work, mirrors, decorated ceramics, carved jade or wood – would have been facilitated by the development in the Han dynasty (206 BC–AD 200) of the Chinese junk with its high poop and large watertight compartments below deck. The trading items that Spice Island mariners sailing double-outriggers might choose would need to be more compact. Spices were an ideal trade item for traders sailing on a double-outrigger because they represented compact wealth. The seeds and cuttings of American plants to be introduced to India, and tobacco and cocaine to be sold to Egypt, also of low volume, would be likely trade choices.

Some prehistorians have suggested a luxury trading motivation for Chinese contact, with Mesoamerican and South American hallucinogenic drugs and jade as highly sought trading items [4]. It seems possible that Spice Islanders also may have voyaged to America to obtain tobacco and cocaine to trade along with their own spices to Egypt and Europe: that is, there is a possibility that they may have established what amounts to an intercontinental trade in tobacco and cocaine bridging two oceans.

That an intercontinental trade in hallucinogenic drugs existed seems clear. Alice Kehoe [5] summarizes the evidence for this international transoceanic trade:

> Tobacco leaves, identified as American tobacco, were chopped up, along with narcissus leaves, and stuffed into the viscera of Pharaoh Ramses the Great, revealed by a French autopsy of the mummy published in 1986. Nicotine and coca metabolites have been identified by the German forensic chemist, Svetlana Balabanova in hair, bones, and skin of Egyptian mummies from the first millennium BC to early centuries A.D., and in pre-Columbian skeletons from China and Europe.

Of comparable interest to the discovery of cocaine and American tobacco in Egyptian mummies is the discovery of hashish (*Cannabis sativa*), an Old World plant, in Peruvian mummies dating to before AD 200. Residues of tobacco and cocaine were found in these mummies together with hashish imported from the Old World [6]. This evidence suggests a two-way trade between the New and Old Worlds in hallucinogenic drugs, use of these drugs before AD 200 in both Old and New Worlds and their use in Peru, Egypt and China in the same triple combination of cocaine, nicotine and cannabis.

Though Chinese traders may also have been involved in this trade, the pattern, dating, sequence and range of first-wave Spice Island maritime exploits, with maritime trading in two oceans before 1000 BC, supports the likelihood that if American cocaine and tobacco reached Egypt in both first- and second-wave periods, and especially as early as the second millennium BC, they may have been traded by Spice Island mariners. This trading would have involved long-distance voyaging in two oceans – following the Kuro Shio Route to Japan and then east to America and back to the Spice Islands. From there Spice Island mariners may have followed a coastal route through the northern Indian Ocean via India to the Red Sea and Egypt or via the faster transoceanic Cinnamon Route to east Africa and so to Egypt and Europe.

We have argued that for 30,000 years during the last Ice Age Spice Islanders were in a position to exploit the trading advantage of a pivotal position giving them access not only to the West Pacific Warm Pool but also to two oceans and two ancient continents. We have also argued that the pivotal position of the Spice Islands gave them access to two biological zones, Asian and Pacific. We have suggested that the Spice Islanders' early role in animal and plant domestication exploited their access to these two biological zones and that following the Kuro Shio Current to America would have given Spice Islanders access to a third biological zone. Accessing hallucinogenic plants in the New World, and in the case of hashish, trading an Old

World plant to the New, was in keeping with their maritime and horticultural history: Spice Islanders had been engaged in plant domestication and the trading of medicinal drugs for millennia.

The medicinal qualities of the spices they traded enhanced their trading value, gave Spice Islanders access to medical markets and enabled them to trade cloves and cinnamon to Egyptians for use in embalming. The discovery of American tobacco and cocaine in Egyptian mummies suggests the same exploitation of the antiseptic and medicinal qualities of the American plants. The medical use of cocaine for pain relief is suggested, for example, by evidence in Egyptian mummies for pre-death ingestion of cocaine [7]. The presence of Old World hashish in Peruvian mummies, along with New World tobacco and cocaine – the triple combination also found in Egypt – suggests the possibility of a two-way trade in medicinal drugs by Spice Island traders who for millennia had been able to recognize and exploit the trading value of medicinal plants.

Though it may never be proven that Spice Island mariners traded American drugs to Egypt or that they traded American plants to India over a span of 2,600 years, it is certainly conceivable. Considerable horticultural expertise would have been needed for choosing American plants for trade and for assisting in their successful translocation to various regions, climates and growing conditions in India. In almost all cases traders would have been introducing food and medicinal plants already domesticated in America. The Indian bas-relief sculptures of corn, for example, show domesticated varieties not primitive cobs. Some varieties of American plants can indeed be sourced to specific American cultivars growing in specific areas in America: the peanuts that reached China and India are known, for example, to be similar to those of Peru. Sometimes the names of American cultivars accompanied the plants.

The implications of the possibility that Spice Island mariners may have traded American plants to India are quite startling – involving, we will suggest, contact with America perhaps as persistent and prolonged as that claimed by diffusionists for the Chinese. If it could be established that Spice Island traders were responsible for the trading of American plants to India, the Indian archaeological evidence we consider in the next section would establish a date for first-wave Spice Island contact with America by at least 1600 BC.

8.3 Archaeological Evidence for the Introduction of American Plants to India

Sorenson and Johannessen's *Scientific Evidence for Pre-Columbian Oceanic Voyages to and from the Americas* [1] provides the clearest picture to date of the history of global plant movements. We cannot hope to summarize their three-volume extensive amalgam of botanical and associated archaeological evidence. Our aim is to consider some of their research findings and to explore some of the conceivable implications of their research for the history of Spice Island contact with America.

The most striking facet of Sorenson and Johannessen's study of transpacific plant movements is that India was the destination for 50% of the plants introduced to the Old World from the New, and that 70% of all the plants introduced to India were food plants. These included the cashew, pineapple, three species of annona fruit, custard apple, sweetsop, peanut, capsicum, chili pepper, Hubbard squash, butternut squash, pumpkin, edible sedge, ribbed gourd, phasey bean, yam bean, kidney bean, lima bean, monstera deliciosa, basil, prickly pear, jicama, ground cherry, sunflower, arrowroot, maize and soapberry. Medicinal plants included the Mexican prickle poppy, datura, cow-itch (whose seeds were aphrodisiac), black nightshade, common and dwarf marigolds (which promote wound-healing) and the vegetable sponge. Medicinal plants represent 20% of the plants introduced to India. Only five of the food plants that went to India were also introduced to Polynesia: the pineapple, yam bean and soapberry – with edible sedge and arrowroot introduced to Easter Island only. We observe, however, that Eastern Polynesia lay outside the transoceanic trade routes that we have been considering. The introduction of American plants to Eastern Polynesia can only have occurred directly through Eastern Polynesian contact with America, probably during the Medieval Climatic Optimum, or indirectly via Hawaii, Micronesia, Western Polynesia or Wallacea.

Three of the earliest introductions to India, clearly first-wave introductions, the yam bean, peanut and sweetsop, were discovered in a cave in Timor occupied between 3,500 and 1,000 years ago, suggesting that they may also have been introduced into the Spice Island region or at least been conveyed to the region by Spice Islanders. Only six of the food plants introduced to India were also introduced to China: the peanut, Hubbard squash, butternut squash, pumpkin, the yam bean and maize. With the exception of the peanut and possibly maize all of these plants were late second-wave introductions, with no archaeological evidence for their introduction before the 6th and 7th centuries AD.

Direct Indian contact with America over a long span seems unlikely: any cultural evidence for possible Indian contact seems to be confined to the 6th and 7th centuries AD. And it seems to be generally agreed that the likelihood is that perceived Indian influences on Mesoamerica in this period would have reached America indirectly from hinduized Java or Cambodia [8]. Contact as late as this could not explain first-wave acquisition of American plants.

Sorenson and Johannessen offer evidence for the introduction of 40 American plants to India over a period from 1600 BC to about AD 1000 (with a 600-year hiatus during the global cold period). We briefly consider the archaeological evidence for some of these introductions below. Sorenson and Johannessen suggest that a further ten American plants may have been introduced to India in this period.

8.3.1 First-Wave Introductions of American Plants to India

In the light of our paradigm, the timings for the introduction of American food and medicinal plants to India are interesting. The kidney bean (*Phaseolus vulgaris*), the lima bean (*P. lunatus*) and the phasey bean (*Macroptilum lathyroides*) are clearly first-wave introductions. Sorenson and Johannessen record that all three have

> been discovered in multiple archaeological sites in India of the 2nd millennium BC. . .Pokharia and Saraswat (1998–1999, 99) report that Phaseolus "beans of American origin have been encountered from proto-historic sites in peninsular India." *P. vulgaris* was recorded from the pre-Prabhas and Prabhas cultures at Prabhas Patan, Junagadh Dist., Gujarat, dated from 1800 BC to AD 600. They also came from Chalcolithic Inamgaon (about 1600 BC), Pune Dist., Maharashtra, and from Neolithic Tekkalkota, Bellary Dist., Karnataka, with a radiocarbon date of 1620 BC. *P. vulgaris, P. lunatus*, and the phasey bean have also been recorded by Vishnu-Mittre, Sharma, and Chanchala (1986) in deposits of the Malwa and Jorwe cultures (1600–1000 BC) at Diamabad in Ahmednagar Dist., Maharashtra. The phasey bean was also found at the Sanghol site (Pokharia and Saraswat 1998–1999, 99), dated in early AD times (Part One, p. 42).

Three annona species were taken to India. The fruit and leaves of the sweetsop (*Annona squamosa*) "depicted at Bharhut Stupa place the plant in India by the 2nd century BC (Gupta 1996, 19–20)" (Part One, p. 25). That is, it is a second-wave introduction. But the custard apple (*Annona reticulata*) is referred to in a text assigned to the 6th century BC. The latter date may imply a first-wave introduction for the custard apple, as also for the pineapple pictured on an Assyrian bas-relief of the 7th century BC (p. 24), the introduction of these plants necessarily preceding the global cold period which would have begun some centuries earlier.

Dating for a first-wave introduction to India of the Mexican prickle poppy (*Argemone mexicana*) is certain. Sorenson and Johannessen note that "An archaeological find of *A. mexicana* seeds at Narhan in Uttar Pradesh assures us that the plant was being grown in India, possibly as a medicinal drug, as early as 1100 BC (Pokharia and Saraswat 1998–1999, 90, 100)" (p. 25).

8.3.2 First-Wave Introductions of Old World Plants to America

There is evidence also for three first-wave introductions of Old World plants to America. The first is of an Old World plant (*Luffa cylindrica*) known as the "vegetable sponge". Sorenson and Johannessen tell us that

> It was grown in South and Southeast Asia (Brucher 1989, 267) where it played a significant role in medicine (Nayar and Singh 1998, 14–15). It has also been cultivated for a long time in the Americas, according to Heiser (1989; 1985). . .Kosakowsky et al. (2000, 199) excavated pottery on coastal Guatemala dating around 1200 BC that had been decorated by daubing the pot's surface with paint using as a tool the unique cut stem end of *L. cylindrica* (p. 35).

Another first-wave introduction of an Old World plant to America may have been the banana (*Musa balbisiana* × *acuminata*). Sorenson and Johannessen tell us that "a word has been reconstructed in the proto-Mayan language dating to the 2nd millennium BC that is glossed by Kaufman and Norman (1984; followed by England 1992, 25) as platano, banana" (p. 39). Though its geographical origin may have been the Bay of Bengal, the banana underwent domestication in Wallacea that rendered it sterile. The preservation in America of varieties with seeds suggests a very early introduction to America from Wallacea.

A third possible first-wave plant introduction to America was of *Morus celtifolia*, a paper mulberry similar to the plant used by many Asiatic papermakers, which Sorenson and Johannessen tell us were identified by Von Hagen "in the taxonomy of over 60 years ago" as a tree whose bark was still then being made into paper by the Otomi Indians of central Mexico (p. 38). They note that stone bark beaters, dated to 1500 BC, identical to those used in Sulawesi in Wallacea, were excavated by MacNeish et al. [9] in the Tehuacan Valley of Mexico and that as Tolstoy [10] had "demonstrated that the bark cloth/paper complex of Mesoamerica was parallel in great detail to bark-processing methods in island Southeast Asia", there appears to be evidence for the ancient introduction of the white mulberry (*Morus alba*) to Mesoamerica from Wallacea along with the technology for making cloth and paper and the stone bark beaters found in the Tehuacan Valley.

Aside from the peanut, which could have been brought back to Southeast Asia by either anomalously early Spice Island or Chinese explorers 4,000 years ago, and a possible early introduction of maize, the earliest plant introductions into China, as we have noted, appear to be late second-wave introductions made in the 6th and 7th centuries AD. In other words, the Indian botanical and archaeological evidence suggests that first-wave Spice Island mariners could have been actively procuring and trading American plants to India 2,000 years before second-wave Chinese traders began introducing American food plants to China.

The fact that there may be little chance of obtaining evidence for either first- or second-wave spice trading with America does not invalidate the secure Indian botanical and archaeological evidence for the introduction of American plants to India. Whether or not Spice Island traders were responsible for trading American plants to India, this evidence needs to be explained. Nor does it invalidate the evidence just presented in which Wallacea appears to be the source both for an early introduction to America of banana species with seeds and for the 1500 BC paperbark beaters found in an area where Wallacean paperbark trees were still growing in the 20th century and where paper and cloth making were still being practised using ancient Wallacean techniques. Arguably China had early paper making but the domestication of bananas in China has never been proposed and the ancient stone bark beaters found in America were identified not as Chinese but as Wallacean.

8.3.3 Second-Wave Introductions of American Plants to India

Archaeological evidence for some of the earliest plants to be introduced to India in the second-wave period of Spice Island voyaging at the end of the global cold period in about 400 BC is listed below. The earliest was possibly one of three Argave species to have reached India. Its fibres combined with plant resins were used in caulking a Greek ship sunk at Kyrenia in Cyprus in the 4th century BC [11]. Whether this plant reached Greece from the Spice Islands via the Cinnamon

Route and east Africa or through trade with India is unclear. It could have been a late first-wave or very early second-wave introduction to India.

Sorenson and Johannessen tell us that the cashew (*Anacardium occidentale*) and sweetsop (*Annona reticulata*) are shown on a bas-relief at Bharhut Stupa in India dated to the 2nd century BC. The datura (*Datura stramonium*), a medicinal, aphrodisiac, hallucinogenic drug, and the black nightshade (*Solanum nigrum*) were both found in an excavation site at Sanghol, dated to the 1st to 3rd century AD. The sunflower (*Helianthus annus*) is depicted on sacred sculptures in India dating to the beginning of the Christian era. *Portulaca oleracea*, which was introduced to India, has been dated to the time of Pliny in Rome, 1st century AD. Cow-itch (*Mucuna pruriens*), an aphrodisiac, is mentioned in an Indian text dated to before the rise of Buddha. Guava (*Psidium Guajava*) is mentioned in a Karaka Samhita text dated to between 900 BC and the 4th century AD. Chili peppers (*Capsicum* spp.) are mentioned in Indian sacred texts dated to the 6th to 8th centuries AD. The Hubbard squash (*Cucurbita maxima*) is mentioned in an Indian medical text of the 7th century AD, the pumpkin (*Cucurbita pepo*) in a 9th century Indian medical text, the marigold (*Tagetes erecta*), a wound-healer, in an Indian text dated to the 13th century AD.

All but the pumpkin and the marigold arrived in India before AD 800, a suggested end limit for the appearance of plank-built boats in southern California. As for all the plants above which are mentioned in Indian texts, the dates for the Indian texts in which pumpkin and marigold are mentioned may be well after the time of the plants' first introductions. Similarly the appearance of plants on stone sculptures may also considerably post-date their arrivals in India. Yet it is possible that the sequence in which the American plants that reached India are recorded may nevertheless reflect the sequence of their arrival. The distinction between first-wave and second-wave introductions is clear. That plant introductions to India were suspended during the cold period is equally clear.

Although some will see Spice Island responsibility for the trading of American plants to India as entirely conjectural, there is some evidence supporting the possibility. Given how robust the botanical and associated archaeological data is, the voyaging implications are significant. If Spice Island traders were responsible or partly responsible for this horticultural trade, the timings for the introductions of these American plants to India support the soundness of the prediction inherent in our paradigm that both first- and second-wave Spice Island explorers and traders followed the Kuro Shio Current to its continental limit on the southern Californian coast of America. More radically, however, the timings for these plant introductions document a frequency of voyaging to America very much greater than that implicit in the Californian archaeological evidence for just one first-wave voyage and between one and two second-wave voyages.

8.4 Estimating the Frequency of Transpacific Voyages

An advantage in trading spices, plants and drugs, we have suggested, is their compactness, their low volume in relation to the carrying capacity of the watercraft being used, especially if double-outriggers or sailing rafts were involved. The disadvantage of the low carrying capacity of sailing rafts and double-outriggers is obvious compared either with later Polynesian double-canoes or the Chinese junk. But transfers of beans and seeds and tubers, as of spices, involved low volume. We have seen that probably by 6,000 years ago Spice Island mariners had access through a coastal trading route to India and probably by 3,500 years ago had access using the Cinnamon Route and Africa to the Middle East and Europe. Certainly it could be claimed that by 1500 BC Spice Islanders were in a position to carry out low-volume trade spanning two oceans. Sorenson and Johannessen's evidence implies Spice Island contact with America by 1600 BC.

Figure 8.1 shows a conceivable trading route spanning two oceans and combining two ocean loops: the Kuro Shio loop in the northern Pacific and an extended clockwise loop in the northern Indian Ocean. The extended loop follows the Equatorial Current to east Africa and then continues north along the east coast to join in turn the Southwest and Northeast Monsoon Drift. This east-flowing current reaches and flows south along the Malabar coast of India before flowing to the west coast of Sumatra. Such a route would have been convenient for traders who combined spice trading to east Africa and the Malabar coast with trading American plants to India.

It is possible that the loss of some spice-growing islands to foreign control in the early centuries of the first millennium AD may have re-directed some Spice Island traders into the rare plant trade. The majority of plant introductions to India from America seem to have taken place after 400 BC. This could, of course, partly be a product of the difficulty of finding archaeological evidence for what may, in some cases, have been earlier introductions. But just as reasonably it may reflect

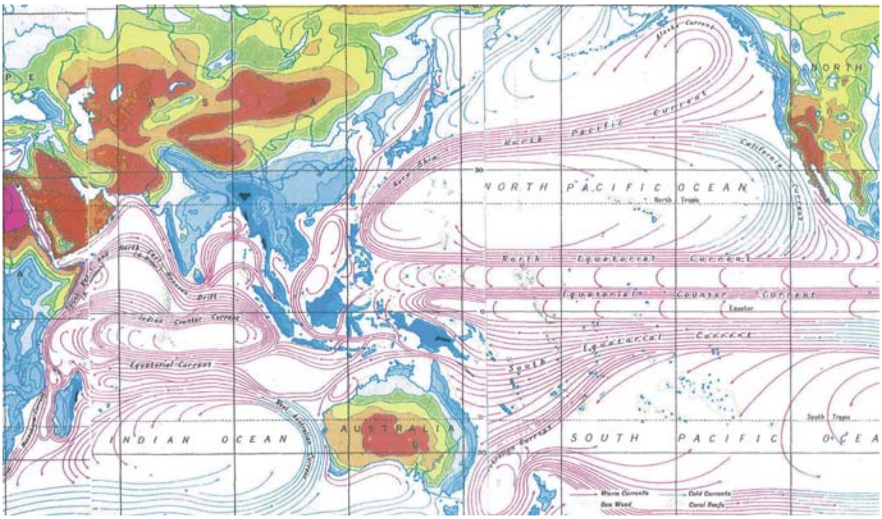

Fig. 8.1 A map showing ocean loops in two oceans which might have facilitated Spice Island trading of American plants to India. (Based on a map of world ocean currents on pp. 12–13 of *The Times Concise Atlas*, Australian edition 1976.) Copyright Times Newspapers Ltd and John Bartholomew and Son. Reproduced with permission from HarperCollins Publishers

the Spice Islanders' loss of direct control of spice sources. The capacity for long-distance transoceanic trading from the Spice Island region seems to have lasted at least to AD 600 in the Indian Ocean [12] (though, long before this, trading using indigenous mariners may have been under foreign control). In the Pacific Ocean it possibly lasted till AD 1000. There is traditional evidence of long-distance oceanic migration from the Spice Island region to Hawaii till AD 460 and to New Zealand till the time of Rakaihautu in about AD 840, perhaps reflecting a continuing history of foreign dispossession for indigenous spice growers in the Spice Island region.

If Spice Island rare plant trading to India took place over a period of 2,600 years (minus the 600-year global cold period) this might suggest that coastal trading to India from the Spice Islands continued up till the end of the American voyaging period, probably till AD 1000. The picture this suggests is of Spice Islanders specializing in a luxury spice and rare plant trade. Egypt, the Middle East and Europe were the major market for their spices and for American hallucinogenic drugs, India their major market for American medicinal and food plants.

Given traditional evidence that explorers travelled in a pair of canoes and migrants in a fleet of six or seven, it seems likely that traders would have travelled in a group of two or three canoes to allow for ocean rescue and for protection at their destinations. Pliny the Elder records that in his time the Cinnamon Route had a turn-around time of five years [13]. Perhaps, as Beale's replica voyage has demonstrated, since double-outriggers with a following monsoonal wind could sail at five knots, making the trip to east Africa a matter of weeks rather than years, Pliny's sources were inaccurate or claimed, rather, that the Cinnamon Route was only sailed every five years.

If the Kuro Shio Route was sailed to America every 20 years and there were 2,000 years of climatically feasible voyaging times, as estimated from evidence for the timings of Indian plant introductions, we are looking at a 100 voyages to America, not the 1–3 voyages implicit in the American archaeological evidence for the diffusion of Polynesian fishhooks and sewn plank technology to southern California. The contrast between the different implied voyaging frequencies for the two sets of evidence makes clear that, where the question of voyaging frequency is concerned, the Indian plant evidence introduces us to another evidence domain. Of the fully authenticated plant introductions 7 reached India before 1000 BC, 33 between 400 BC and AD 1000. Plants are unlikely to have been introduced only once. We are probably looking at multiple introductions of a range of varieties for each plant. Indeed, the multiple Sanskrit names in India for many of the introduced plants suggests the introduction of different varieties of the same plant over time or their introduction to different regions or early introduction and dispersal with variations in names over time marking their spread. Probably many batches of each variety were traded in successive voyages while market interest in that variety was at its height. In comparison, over about 200 years, 70 varieties of kumara were either introduced to New Zealand or developed in New Zealand by medieval Polynesian migrants. Trialling different varieties of the same American plant for their appropriateness to a range of growing conditions in India would have taken time and persistence and would have taken considerable horticultural skill on the part of the traders choosing plants in America.

We note that although Sorenson and Johannessen offer no suggestion as to which traders brought the American plants to India, they independently conclude that a large number of voyages to America would have been needed to bring the cited plants to India:

> The data in this book show that as many as 50 species of plants definitely, or very possibly, were transferred between the American tropics and India, or vice versa, before Columbus' day. While we cannot tell how many voyages this long process involved, there must have been several score – or maybe several hundred – stretched over millennia (Part One, p. 69).

The question of voyaging frequency demands some consideration of the practical implications of maintaining the persistent maritime trade contact with America (by whomsoever was responsible for the trade) that is suggested by the Indian data. Trading with America would have demanded considerable knowledge and experience on the part of the traders. They would have needed established contacts in America to help them access suitable plants especially where plants were not coastal; contacts with whom they could organize trading exchanges and who could secure future orders for the items they were trading to America; knowledge of safe harbours and coastal hazards; knowledge of protocols for dealing with different tribes or with appropriate members of urban hierarchies. This kind of necessary practical knowledge and experience could more readily be passed on from experienced traders to "apprentices" in the trade if the apprentices accompanied them on a voyage to acquire experience at first hand. We are not talking once-a-generation voyages. At least two voyages per generation – say every 12 or 15 years – might be needed to account for the persistence of contact that is implicit in the Indian archaeological evidence for the spread of plant introductions in the period of greatest plant trading from 400 BC to AD 800.

The scenario we are proposing suggests, then, a frequency of transpacific voyaging far greater than that implicit in the Californian archaeological data of one late first-wave voyage and of one or two late second-wave voyages. The Indian data provides a richer evidence domain for assessing the timings, frequency and range of transoceanic contact. It is not irrelevant that the plant trade to India would have involved voyaging in two oceans. Both during the last Ice Age and after the drowning of Sundaland, Spice Island traders had been able to exploit the pivotal position of their archipelago with access to two oceans and access to two regions with very different biologies. We have suggested that it is hardly coincidental that Wallacea with access to both biological regions was a major centre for early plant and animal domestication. Nor that the Spice Islanders' role in plant translocation may have continued once crossing the Pacific opened up a new biological region for them to exploit. As we saw in Chapter 7, Spice Islanders could bring to the role of plant trading a horticultural sophistication and awareness honed through a long history engaged in genetic modifications both of plants and animals in Wallacea.

The evidence Jett summarizes for persistent Chinese cultural, artistic and technological influence on the major prehistoric American civilizations challenges the anti-diffusionists' belief in an independent, non-derivative evolution for these major civilizations. Anti-diffusionists challenge diffusionists' cultural and artistic perceptions of parallels between Chinese and New World cultures on the grounds that they do not meet the requirements for scientific evidence. The same grounds for objection cannot, however, be levelled at Sorenson and Johannessen's biologically and archaeologically secure Indian evidence for persistent transpacific contact with America. Whether Chinese or Spice Island traders or both were responsible for trading American plants to India, we are dealing not only with a more extensive but also with a more secure evidence domain.

8.5 Transoceanic Trading

Early traditional accounts show oceanic migrations from the Spice Islands to have been mostly triggered by tribal defeat and the threat of tribal extinction. Later traditional accounts show medieval migrations within and from Eastern Polynesia were triggered by population pressures, famine and associated conflict over land and resources. But trading is ipso facto economically motivated and the earliest migrations and conjectured migrations to Micronesia, Japan and Madagascar can perhaps most plausibly be accounted for as supplying needed rest and supply stations on long-distance trading routes. That is, there was a primary economic motive for their establishment. One of the primary motivations for exploration is trading expansion. A search for new trading opportunities may well have motivated the earliest Spice Island exploratory forays into both the Indian and Pacific Oceans. Certainly the conjectured establishment of an early oceanic trading route to Japan and the certain establishment of the much longer Cinnamon Route across the Indian Ocean place spice trading high on the list of motivating factors for exploration in both oceans and for trade-associated colonizations.

A strong economic motivation would explain the long and persistent contact with America that is implicit in the Indian data, especially in the period of strongest plant trading activity from 400 BC to AD 800. We have suggested that it is possible that the increased activity of this period may have coincided with the Spice Islanders' increasing loss of control over spice sources after AD 76. If this was the case, there could have been some compensatory, economically motivated, redirection in the focus of their horticultural trading with increased trading of exotic plants to India from America. In their trading with America, Spice Island traders were presumably free of the competition from foreign traders and attacks from other tribes that, tradition tells us, plagued them in the Spice Island region and triggered many migrations from it. That Spice Islanders traded spices to America in a two-directional trade is conceivable but, given the archaeological fragility of spices, it is unlikely that archaeological evidence for spice trading with America will ever be discovered unless evidence is found for the use of cloves and cinnamon as well as of hashish in Peruvian mummies or advances in molecular science can demonstrate the presence of Moluccan spices in America from the merest traces.

The voyaging and trading implications of the Indian data gathered by Sorenson and Johannessen imply the possibility of a second-wave extension or intensification of a horticultural trade that, even for first-wave Spice Island traders, by 1600 BC may have combined spice trading and the trading of American plants to India. Greater emphasis on plant trading in the 1,400 years of potential second-wave Spice Island contact with America after 400 BC suggests the possibility that horticultural trading, which had been the driving economic force throughout the Spice Islands' long maritime history, may have remained the main driving force in later maritime trading even though, for the last 800 years of the second-wave period, Spice Island maritime control of, or access to, spice sources may have been consistently eroded by foreign competition. In a wider context, over a period spanning 2,600 years from the trading of cloves to Terqa to the fall of the Maya, Spice Island horticultural trading can conceivably be seen as the singular persistent economic force driving the Spice Islanders in their exploration and settlement of the northern Pacific and of the Indian Ocean and in the persistent maritime contact with America, east Africa and India that is suggested by the Indian plant data and by historical evidence for repeated sailings of the Cinnamon Route.

Despite the strength of Sorenson's and Johannessen's botanical and archaeological evidence, the role we have ascribed to Spice Islanders as rare plant traders can only be conjectured. It is possible that Chinese traders may have traded American plants to India by combining maritime and overland routes. It is possible that Spice Island and Chinese mariners may both have been involved in trading American plants to India. The implications of possible Spice Island involvement, however, are significant enough to encourage even a conjectural consideration of their role in this trade. The trade certainly existed and Spice Islanders had the motive, means and opportunity to pursue it. They had the needed maritime and horticultural backgrounds and skills, a long history of transoceanic exploration, trading and migration, based on following West Pacific Warm Pool currents, a long history of plant domestication in Wallacea and mastery of transoceanic voyaging in two oceans. They are known to have exploited the oceanographic strategy of following powerful warm currents to their continental limits in the Indian Ocean over a comparable time span and distance. Spice Island involvement in the transoceanic plant trade that Sorenson and Johannessen document might be seen as a logical extension of a 40,000-year-long history of horticultural trading and plant domestication. It can even be seen as the realization of the full trading potential inherent in their exploitation of the strategy of following West Pacific Warm Pool currents to their limits in two oceans.

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Chapter 9
Exploration Strategies, Settlement Sequence and the Evolution of Canoe Design

Abstract Spice trading and associated conflict can be seen as central factors driving Spice Island migration history. Initially colonizing endeavours were linked to opportunities for spice and obsidian trading (Japan, the Bismarcks, Madagascar). Primacy for defeated tribes, when spice resources had been wrested from them, was given to uninhabited islands with the largest land areas (Madagascar, New Zealand, Island Melanesia, Western Polynesia, Hawaii, possibly in that order). Settlement priorities changed with time. Avoiding hypothermia initially meant priority for colonizing closer lands. The spur of spice trading led to more distant settlements as did the attractions of significant land area and rich biota. Late migrations to Eastern Polynesia required evolution in sailing strategies and canoe design.

Keywords Settlement sequence · Later settlement of Eastern Polynesia · Canoe design · Sailing strategies

9.1 Introduction

Our paradigm embodies the idea that following powerful warm currents flowing out of the West Pacific Warm Pool into colder oceans dictated the sailing strategies that Spice Island mariners adopted in transoceanic voyaging in the Pacific and Indian Oceans. We have suggested that this strategy was rooted in conditions and in experience in their West Pacific Warm Pool nursery that propelled them into long-distance voyaging. But exploiting fast warm currents was not only a means of ensuring speed and thus of combating hypothermia. It also provided an extremely effective mode of exploration. The Coriolis effect, which is governed by the rotation of the Earth, determines the pattern and behaviour of ocean currents worldwide. The major currents in the northern hemisphere travel in clockwise loops between enclosing continents. In the southern hemisphere the loops are anti-clockwise. As a current reaches a significant landmass – a large island or continent – part or whole of the current turns towards it, travels some way north or south, depending on the hemisphere, and then reversing, flows in the opposite direction usually back across the ocean. An explorer following a fast ocean current, alert for this sign, could estimate,

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by the extent of part or whole of the turning current, the size of the island drawing the current to it or the fact that he was reaching a continent.

Because part of a major ocean current changes direction as it approaches a landmass, such a change would immediately alert an explorer to the nearness of land. Prehistoric explorers following the East Australian Current that flows south past New Caledonia along the eastern coast of Australia, for example, would have known as soon as a large part of the current at its eastern edge turned towards the South Island of New Zealand that this signalled the presence of land. They would also have known what to expect if they followed that part of the current as it moved towards the land and, reversing direction, flowed along its length. They would have realized that the reversed current would carry them back at least some way towards their homeland or the starting point for their journey. And, from the very width of that part of the southward flowing current that diverted to flow towards the South Island, they would have realized that the land they were about to discover was no mere pinprick in the ocean but very large indeed.

Figure 9.1 clearly shows that the East Australian Current is fed by the South Equatorial Current. Indeed this current feeds the West Pacific Warm Pool itself.

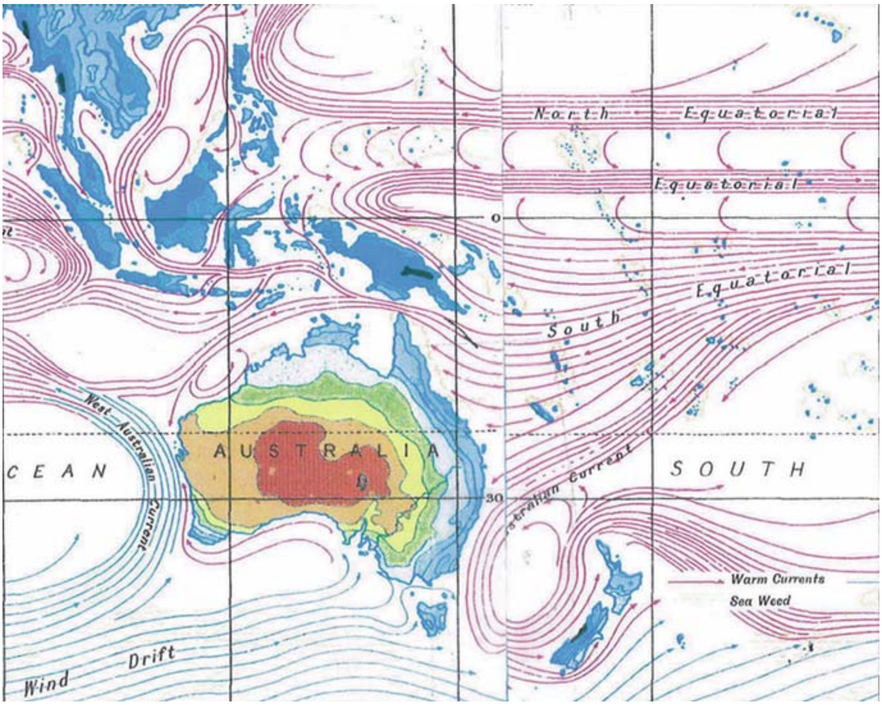

Fig. 9.1 The East Australian Current Route to New Zealand from the Spice Islands. (Based on a map of world currents on pp. 12–13 of *The Times Concise Atlas*, Australian edition 1976.) Copyright Times Newspapers Ltd and John Bartholomew and Son. Reproduced with permission from HarperCollins Publishers. The response of the East Australian Current to the landmass of New Zealand is particularly striking

Currents and winds giving optimal access to the East Australian Current through the two northern routes from the Spice Islands (above New Guinea and below New Guinea) can change seasonally, determining optimal timing for voyages and optimal voyaging route for joining the East Australian Current. A fast passage to New Zealand would be facilitated by a strong El Niño, able to reverse or weaken the South Equatorial Current as it flows towards New Guinea. More significantly, an El Niño would provide a strong northerly wind to hasten the passage south. In sailing the Cinnamon Route, the timing for optimal wind conditions similarly determined the timing for voyaging because the Cinnamon Route relied on power from monsoonal winds as well as from a strong current to cross the long distance without landfall from Christmas Island to Madagascar.

The practical consequences of understanding the predictable pattern of ocean currents is obvious: it would have facilitated a rapid search for the largest islands in the Pacific and Indian Oceans. Instead of sailing in cautious arcs looking for islands within a safe easy sailing range, early explorers could have committed themselves to following strong currents and, by watching for diverging edges in the current, been guided to new lands.

Following fast warm ocean currents as an exploration strategy in a warm global period would have enabled Spice Island explorers to quickly discover the largest uninhabited islands open to settlement: Madagascar in the Indian Ocean, New Zealand in the south Pacific and the small but fertile Hawaii in the north Pacific. With a current-based exploration strategy, the largest lands that could be reached by WPWP currents would be discovered first because the larger the land the more obvious the current divergence. If the lands they discovered were uninhabited they would naturally become potential migration targets. Migrating to the newly discovered lands was a matter of following the same fast warm current the explorers had used, with the current itself, through its diverging edge, guiding colonists to their destination.

A west–east, nearest-to-most-remote paradigm is associated with the stepwise settlement of Eastern Polynesia from Western Polynesia. If we set this paradigm aside as not relevant to the current-based settlement of the Pacific from the Spice Islands, it is interesting to consider instead the more usual criteria for determining settlement sequence: land area and richness in natural resources.

Current-based exploration would have made possible the early discovery of the largest uninhabited islands in both oceans: Madagascar at over half a million square kilometres in area and New Zealand (265,000 km^2). Though both were a long voyaging distance from the Spice Islands, they could be reached directly by following major currents flowing out of the West Pacific Warm Pool.

Migration targets with significant land area closer to the Spice Island were the Bismarcks and Solomons, which together constitute a larger land area (77,000 km^2) than the total areas of Western Polynesia (22,000 km^2), and Island Melanesia, including New Caledonia, and all the intervening archipelagoes (40,000 km^2). The Hawaiian Islands, rich in resources, had a land area of 17,000 km^2 and could be reached through following a major WPWP current. These islands may well have provided a rest and supply station on the Kuro Shio Current route to America. All other Pacific archipelagoes have areas of less than 2,000 km^2 and all but the

Marquesas (1,200 km^2), Carolines (1,200 km^2) and Tahiti (1,000 km^2) have less than 1,000 km^2.

An early settlement of the Bismarcks and Solomons is perhaps predictable from land area alone. However, for Spice Islanders as major maritime traders, trading opportunities may well have provided a stronger motivation for colonization than land area and richness in natural resources or small distance from the Spice Islands. Taking possession of the valuable trading resource, Talisean obsidian, may well have triggered settlement of the Bismarcks and Solomons, which had possibly been depeopled by the Mt Witori eruption. The establishment of an early spice-trading colony in Japan, we have suggested, would probably have been in response to trading opportunities and priorities. An early settlement of Madagascar as a rest and supply station on the Cinnamon Route, likewise, may have been largely a matter of securing trading opportunities, though as a large uninhabited island, Madagascar would have been additionally attractive to migrants.

It seems likely that Madagascar and New Zealand may have been settled before Island Melanesia and Western Polynesia both on the grounds of their significant land areas and in the case of Madagascar of its trading relevance. It also seems likely that the archipelagoes of Eastern Polynesia would be the last to be settled, not solely because of the difficulties of reaching them against the trade winds and currents of the southern Pacific (assumed by most prehistorians to be the sole cause for their late settlement). Their small land areas and their remoteness from spice-trading routes, their distance from the Spice Islands, the fact that there were no strong warm WPWP currents flowing to them and their lack of trading resources made them unlikely migration targets for Spice Island traders.

Our central paradigm proposes early extensive exploration of the Pacific and Indian Oceans following three exploration paths, all major currents flowing out of the WPWP. Our paradigm predicts which large uninhabited islands would have been discovered by following these paths. Recognizing these currents as early exploration paths, however, does not enable us to predict the colonizing sequence for the discovered lands. The place of each land in the settlement sequence appears to have depended on a balance of factors but it is clear that this balance varied with time. In the next five sections we consider factors determining variation.

9.2 Settlement Sequence: Avoiding Hypothermia

As the Spice Islanders' maritime skills, experience and confidence grew through their experience of long-distance voyaging, it seems clear that the balance of factors determining migration sequence would have changed. As we have seen, regional voyaging involving trading within the WPWP was extended first to coastal spice trading in the northern Indian Ocean, extended further to current-based transoceanic spice trading following the Cinnamon Route to Madagascar and east Africa in the west and then through following the Kuro Shio Current to Hawaii and America in the east. Initially minimizing the risks of hypothermia seems to have determined the Spice Islanders' maritime strategies. Voyages within and through the WPWP appear to have been favoured over those outside it. And, not surprisingly since length of exposure to wet and windy conditions increases the risk of hypothermia, shorter voyages were probably deemed safer than long ones, with distance seen as a constraining factor. Thus in the earliest colonizing period, it is not surprising to find the clearest evidence for a Pacific settlement is to be found in Palau, which lies close to Halmahera. It seems reasonable to consider the possibility both for a Spice Island colony in the Sepik/Ramu area of New Guinea 6,000 years ago and for a more distant trading colony in southern Japan in the same period. All three – Palau, the northern coast of New Guinea and southern Japan – lay within or were accessible through the WPWP. Given the long north/south spread of the islands of Micronesia, it is clear that the journey to Japan could be divided into short stages.

However, with increasing maritime experience and confidence, other factors seem to have come into prominence. It is interesting that the distance from Halmahera to early settled Palau in Micronesia (the probable first rest stop on a trading route to Japan) is only about 900 km, a quarter of the distance from Halmahera to southern Japan. This suggests the kind of distance the Spice Islanders were confident to attempt perhaps nearly 6,000 years ago in what we suggest as their early enterprise of establishing a trading route to Japan and probably, genetic evidence suggests, of establishing a trading colony there as well.

This distance of 900 km contrasts with the very great distance that had to be bridged probably two and a half thousand years later in establishing the Cinnamon Route. After leaving Timor or Java, possible rest stops could have been made at Christmas Island (about 1,800 km from Timor) and at Cocos Island (about 1,000 km west of Christmas Island). After Christmas Island, mariners faced a daunting stretch of about 5,200 km from Cocos Island to Madagascar or about 4,000 km to Tromelin Island and another 1,200 km from there to Madagascar. Perhaps two and a half thousand years after crossing the WPWP through Micronesia to reach Japan (a voyage of about 3,600 km which could easily be broken into smaller segments), a distance greater than the whole voyage to Japan had to be crossed without landfall to reach Madagascar. Of course, by the time that mariners were sailing from the Spice Islands to Rhapta on the Cinnamon Route, they had had another two millennia of experience, technology and maritime sophistication behind them. And we suggest that in the interval Spice Islanders may have acquired a greater degree of cold resistance and famine resistance.

9.3 Settlement Sequence: The Spur of Spice Trading

In the earliest phase of migration, probably close to 6,000 years ago, spice trading appears to have been the major spur for long-distance voyaging and the main reason for establishing colonies, both as trading bases at or close to journey's end and as rest and supply stations en route. The distance from Halmahera to southern Japan is only about 3,600 km and from Halmahera to New Caledonia about 5,200 km. Southern Japan lies close to (above) the northern boundary of the WPWP in summer and New Caledonia lies close to (below) the southern boundary in winter. They shared the advantage that the greater portion of a voyage to either would in the appropriate season be largely through the warm waters of the WPWP. Although New Caledonia was probably uninhabited, an advantage Japan lacked, the impetus of spice trading with Japan as well as its closeness to Halmahera made it likely that an earlier colony would have been established in Japan.

Similarly the distance to New Zealand from Halmahera (about 7,600 km) is considerably less than the distance from Halmahera to Madagascar (about 9,600 km). Reaching both involved following fast warm currents flowing out from the WPWP through colder oceans. As large uninhabited islands, both were prime colonizing targets. But although the distance to Madagascar was greater than that to New Zealand, again one could predict that the impetus of spice trading for colonizing Madagascar, as a needed rest stop on the spice-trading route to Rhapta, would probably have led to an earlier colonization there. It is interesting that the demographic evidence we offer in Part II and the genealogical and genetic evidence in Part III all suggest that the first settlement of New Zealand may have taken place only a hundred years later than that of Madagascar. With Madagascar and New Zealand as the largest uninhabited islands in two oceans, early settlement of both was predictable.

With southern Japan so close to the Spice Islands (less than a third of the distance to Rhapta) and with most of this distance lying within the warm waters of the WPWP, it is hardly surprising that, as the mitochondrial evidence suggests, the earliest significant Pacific colony was probably established in southern Japan close to 6,000 years ago, two and a half thousand years before the settlements of Madagascar and New Zealand.

The distance from Halmahera to Madagascar at about 9,500 km is close to that from Halmahera to Hawaii (about 9,600 km) and the distance from Halmahera to Rhapta at about 11,200 km is close to the distance from Halmahera to the southern coast of California at about 11,600 km. As we have seen, there is historical evidence that Spice Island mariners traded spices from the Spice Islands to Rhapta probably over a time span of 2,000 years, though of course they could not have done so during the global cold period between 1000 BC and 400 BC. Given the historical certainty that Spice Island mariners repeatedly sailed the Cinnamon Route, it would not be surprising to find that, as the combined botanical and archaeological evidence discussed in Chapter 8 suggests, Spice Island mariners may have repeatedly traversed similar distances following another fast current flowing out of the WPWP. It is clear that Spice Island mariners were as capable of reaching Hawaii and southern California as of reaching Madagascar and Rhapta. That they may have done so over such a long period (2,600 years) is perhaps more surprising. We can only conjecture that such voyaging ventures to America – if Spice Island traders were indeed responsible for the introduction of American plants to India – were economically motivated and assume that the horticultural trading of indigenous American plants to India may have both motivated and sustained this conceivable history of transoceanic voyaging.

Though the distance from Halmahera to Madagascar and Hawaii are similar, again the spice-trading impetus for settling Madagascar together with its very much greater land area suggests that it was probably settled well ahead of Hawaii. But the similarity between single-piece curved shell fishhooks in Hawaii and those that appeared in California before 1000 BC nevertheless suggests that a first-wave settlement of Hawaii took place. Evidence from traditional histories describing the discovery and settlement of Hawaii supports this. In addition there is traditional evidence for second-wave voyaging to Hawaii. It seems likely, as we have noted, that Maui the Navigator (see Chapter 16) had sailing instructions for reaching Hawaii as well as New Zealand, handed down from first-wave explorers, for tradition tells us that his voyage to the more distant Hawaii immediately followed his exploration of New Zealand.

The Bismarck archipelago seems to have been colonized at the same time or slightly earlier than Madagascar. We have suggested that the colonization of the Bismarcks may also have been partly motivated by the securing of trading possibilities: the seizing of obsidian sources possibly abandoned, or left inadequately defended, following the massive volcanic eruption of Mt Witori about 3,600 years ago. Perhaps the de-peopling of the Bismarcks through the eruption also presented a safe colonizing opportunity for Spice Islanders. Long familiarity with this archipelago through obsidian trading possibly stretching back 4,500–9,500 years before this, the opportunity to seize a major obsidian source and the short distance involved may have given precedence to the colonization of the Bismarcks over colonizations of Madagascar and New Zealand. As we establish in Chapter 20, however, the time margin involved may have been only 100 or 200 years.

9.4 Settlement Sequence: Significant Land Area and Rich Biota

Madagascar, New Zealand and Hawaii were prime migration targets: uninhabited islands for first-wave colonists and, for second-wave colonists, newly inhabited lands possessing only small populations which were probably related to their own. Once Spice Island mariners had developed the capacity for crossing vast ocean distances following fast warm currents, even when rest stops were minimal, the defensive advantages of uninhabited islands and the advantages of significant land area and rich biota were probably the major spurs for migration, especially for defeated tribes. Though great distance was perhaps still a disadvantage, it was not seen as insurmountable. For defeated tribes who may have lost spice-growing islands to invaders, the balance of factors determining the primacy of migration targets was tailored to hopes for survival, with distance from their enemies a primary concern. Hopes for new trading opportunities became less relevant.

When the international demand for spices increased in the 1st century AD, conflict and unrest in the Spice Island regions followed, as we have seen, with foreign traders, anxious to secure control over spice resources, possibly promoting inter-tribal conflict. Conflict and unrest undoubtedly triggered migration from the Spice Island region for defeated tribes both then and later as surely as conflict and unrest triggered multiple migrations in tropical Polynesia from about AD 900. There, as we shall show in Part II, conflict over land and resources followed on the heels of El Niño-driven drought and starvation and drove migrations both within tropical Polynesia and south to New Zealand.

9.5 Settlement Sequence: The Problem of Settling on Long-Inhabited Continental Coasts

It seems likely that Spice Island trading colonies would have been established where the lands with which they traded were distant from the traders' home base. One would expect trading bases to be established in southern Japan and America, though a settlement on Madagascar was perhaps close enough to have made the establishment of a trading base in Rhapta unnecessary. Colonizing an uninhabited, easily defensible off-shore island would have avoided the dangers of establishing a trading colony on a long-inhabited continental coast.

Madagascar, as an uninhabited island, possessed a defensive advantage which, along with its great size (over half a million square kilometres), made it an attractive colonizing target. The early traditional histories mentioned in Chapter 5 make clear the problem of trying to establish a colony in an already inhabited country. The quoted example in the whare wananga tradition of New Zealand of an ancient discussion by leaders of a defeated tribe forced to migrate to Borneo, of how to build a pa to defend themselves against attack, makes clear migrants' awareness of their initial vulnerability. There is only very meagre evidence that Spice Islanders ever attempted to establish colonies on the long-inhabited continental coasts to which the major currents they followed drew them: the west coast of America, the east coast of Africa and the east and west coasts of Australia. It is clear that Spice Island mariners explored and may have established a relationship with indigenous peoples on these coasts (teaching the construction of sewn-plank boats to the Chumash and Gabrielino of southern California, for example, and for millennia trading spice through the east African coastal entrepot at Rhapta). Perhaps it was thought too difficult for migrants who were trying to establish permanent colonies to defend themselves initially against indigenous populations on long-inhabited continental coasts.

It seems possible that New Zealand Maori knew of the existence of prehistoric Australia and called it Ulimaroa. There is some traditional evidence for the attempted establishment of at least one New Zealand colony in Ulimaroa. Andrew Kippis, whose *The Life of Captain James Cook* [1] was printed in 1788, had access to Cook's and Banks' journals. He records that Cook, through the Tahitian navigator and interpreter Tupaia, asked Maori in the Bay of Islands if they knew of any other lands. They replied that some of their ancestors had sailed a long time ago to

Ulimaroa, a large land to the NNW of New Zealand. Some of these voyagers had returned, they said, and had described the indigenous people of Ulimaroa as eating pig (possibly kangaroo or wombat, given there were no pigs in New Zealand or Australia). Maori in Queen Charlotte Sound, who were asked the same question through Tupaia, mentioned a canoe with four men reaching New Zealand from Ulimaroa. The four men were killed. The suggestion that if it lay NNW of New Zealand, Ulimaroa may have been New Caledonia is not tenable. Given the significant size of New Zealand, it seems unlikely that Maori would describe New Caledonia as very large. The north-flowing part of the East Australian Current which travels up the west coast of New Zealand flows NNW. It could be followed and then crossed in a series of transverse steps to reach Australia.

The name Ulimaroa itself has been challenged on the grounds that the sound "l" did not exist in Maori. The Polynesian "r" and "l" are different from their closest equivalents in English. The name of the island we know as Ra'iatea is recorded in Cook's journal as Ulietea and Cook wrote kumala for kumara. There is discussion of European distortions in recording the Maori language in Chapter 16. Perhaps the best indication that Ulimaroa was Australia comes from the information encoded in the name. One meaning of *uli* is descendant or race. Thus *uli-a-Tiki* means the descendants or race of Tiki, that is, the human race. But the word also means black-skinned. The word *maroa* carries meanings of extensiveness and of being parched – not inappropriate to Australia as a land that is 80% desert, which is subject to drought and which is indeed an extensive land inhabited by a black-skinned race.

That New Zealand Maori both in the Bay of Islands and in Queen Charlotte Sound knew of the existence of Ulimaroa suggests that Spice Island explorers, following the East Australian Current south from the Spice Islands, may have explored the Australian east coast at some earlier time, just as there is some evidence, as we have seen in Chapter 4, to suggest that Spice Island mariners may have explored the coast of Western Australia. The response of Bay of Island Maori to Cook's question suggests that there was even an attempt to establish a New Zealand colony in Ulimaroa. Whether this colony survived the early risk of extinction faced by any new colony, and especially by one on an already inhabited coast, is unclear but the cultural identity of the colony certainly appears to have been lost. Perhaps this in itself can be seen as illustrating the difficulty of establishing a colony on any of the inhabited continental coastlines to which the WPWP currents led Spice Island mariners.

9.6 Settlement Sequence: A Summary

If a Spice Island base for Polynesian migration history is acknowledged, a logical pattern determining migration sequence in each period becomes clear. Initially opportunities for spice and obsidian trading gave primacy to colonizing endeavours (Japan, the Bismarcks, Madagascar). Primacy for defeated tribes, when spice resources were wrested from traditional owners, was given to uninhabited lands with the largest land areas (Madagascar, New Zealand, Island Melanesia, Western Polynesia and Hawaii, possibly in that order). It seems that after AD 76 when foreign traders moved into the Spice Island region, more distant oceanic migrations were made by defeated tribes following their loss of land in the Spice Islands. This is the pattern described in traditional accounts. The long maritime, oceanographic, horticultural and economic history of the Spice Island archipelago can be seen to have powerfully affected the colonizing history of the Pacific and Indian Oceans. Spice trading and the conflict it generated can be seen as a central factor driving that history, as indeed some would argue it drove later global maritime history. Without its Spice Island base being taken into account, the colonizing history of Polynesia is less coherent, logical and predictable and is significantly diminished. Without its Spice Island base, the focus of Polynesian migration history moves instead, as it has done for the last 50 years, to the so-called Lapita peoples' settlement of Island Melanesia and Western Polynesia and to the later struggle to settle the small archipelagoes of Eastern Polynesia from Western Polynesia. With this focus, the remarkable oceanic explorations and colonizations of both first- and second-wave Spice Island mariners have been lost to sight, though, as we have argued, they are central to an understanding of the history of Spice Island migrations in both oceans and especially central to an understanding of the settlement history of the Pacific.

9.7 Migrations Within and from Eastern Polynesia: Evolution in Sailing Strategies and Canoe Design

The commonly presented map of Polynesia with New Zealand isolated at the bottom apex of the vast Polynesian triangle has fuelled the belief that because New Zealand is so far from Eastern Polynesia and hard to reach, it must have been the last land in the Pacific to be settled. New Zealand is not regarded as being close to New Caledonia (a neighbour so close that, as we have commented, its distance from New Zealand is little greater than the length of New Zealand itself north to south). Rather it is linked with Hawaii and Easter Island, the other two apices of the Polynesian triangle. The early archaeological finds in all three are seen as technologically archaic not because of antiquity but by virtue of remoteness, for Polynesian migrations have been seen as logically sequential, west to east, nearest to most remote.

Ben Finney has shown that tacking against the wind quadruples distances as the bird flies: "To make good one nautical mile against the true wind . . . a Polynesian double canoe must tack 3.9 miles" [2]. This emphasizes the difficulties involved in sailing against the trade winds and associated currents in a west–east colonization of the southern Pacific. But it has little application to the early route south, recorded in tradition, following the powerful East Australian Current to New Zealand. With a strong northerly – and especially a long-lasting El Niño northerly – behind it, a canoe would have fast sailing to New Zealand on this shorter route. The first New Zealanders almost certainly reached New Zealand in Halmaherian double-masted double-outriggers. These would have had the sailing advantage for which they had been designed – exploiting fast ocean currents. The eastern edge of the fast south-flowing warm East Australian Current reverses in response to the landmass of New Zealand and turns southeast towards the South Island, taking a canoe to a landing at Mahitahi (Bruce Bay) on the west coast. There, tradition tells us, Maui the Navigator, following sailing instructions handed down from Lapita times, landed, as the first New Zealanders must have landed before him.

The concept of the Polynesian triangle is, however, useful for highlighting the very real maritime achievements of the Eastern Polynesian navigators and colonizing fleets which voyaged to New Zealand and Hawaii in the medieval warm period. These navigators relied on wind power rather than on the propulsive power of ocean currents. Their achievements imply, and were perhaps only made possible by, a long history of evolution in canoe design. Significant design changes were needed first to bridge the 1,200 km ocean gap between Western Polynesia and Eastern Polynesia against the trade winds and currents of the southern Pacific. Further changes were needed to cope with inter-island and inter-archipelago voyaging within Eastern Polynesia.

As we have noted, by following fast warm currents in the earliest phase of the settlement of the Pacific, Spice Island mariners avoided the difficulties in sailing west–east against the trade winds and currents. The double-outriggers they used to handle fast currents and run before the wind were probably unable to cope with the complications of west–east sailing. Atholl Anderson [3], for example, notes Blust's claim "that the double canoe was invented in Fiji-West Polynesia and, further, that it was the means of overcoming the difficulties of colonizing East Polynesia which had until then defeated the efforts of outrigger seafaring". A different choice of sailing strategies was needed to breach the 1,200 km gap between Western Polynesia and Eastern Polynesia. Canoes had to be redesigned to meet this task. Once Eastern Polynesia had been reached and colonized, evolution of canoe design was likewise shaped by the specialized needs of voyaging in this region.

Anderson noted the range of canoes developed in tropical Polynesia, for example, the Fijian waqa drua, the Tongan kalia, the Tongan tongiaki and their many local derivatives. He points out that these canoe types had highly specialized advantages but often corresponding limitations:

> The drua and its derivatives. . .were fast sailers (4 knots to windward, 10–15 knots off the wind), could point up to 35 degrees into the wind but with heavy leeway, and could carry large cargoes. However they required constant bailing, were very difficult to steer in strong breezes and could not run before the wind, 'the great weight of the sail, held down at the tack to the head of the canoe, combined with the pressure of the wind upon it, caused the canoe to run under instantly when set square before the wind' (Thomson 1908 in Haddon & Hornell 1975: 327). Yet they had one big advantage over earlier double canoes, which was the end-for-end lateen rig (pp. 29–30).

The direction of specialization in Eastern Polynesia was perhaps predictable. Both first- and second-wave Spice Island explorers, traders and migrants exploited fast currents, employing stable double-outriggers with oceanic spritsails, running before the wind. Eastern Polynesia developed less stable canoes which were unable to run before the wind but could shunt, carry heavy cargoes, exploit light and variable winds and paddle through the Doldrums at need. These canoes served specialized sailing needs within tropical Polynesia, both for voyaging within archipelagoes and in inter-archipelago voyaging, carrying larger numbers of people and heavier cargoes.

The kinds of specializations in canoe design seen in Eastern Polynesia underline major differences between the sailing strategies adopted in Eastern Polynesia and the sailing strategies that for millennia made possible the extensive exploration, trading and migration of Spice Islanders. Sail design, for example, reflects changes in sailing strategies. As Anderson notes, the development of the Oceanic lateen sail

> which, typically, has a yard with no boom. . .enabled going about by shunting rather than tacking. . .Shunting was a manoeuvre which kept the same side of the boat to the wind, important for outriggers especially, and it involved switching the bow and stern by taking the heel or tack of the sail from one end of the hull to the other, the mast swivelling over to suit (p. 27).

Tacking, by contrast, involves "turning the bow through the direction of the wind". Eastern Polynesian variations in canoe design supplied greater manoeuvrability and more ability to handle light and changeable winds while maintaining maximum opportunity for paddling. Anderson, after Finney [4], argues that

> East Polynesian double canoes were built traditionally with open hulls, low freeboard (about 60 cm.), and access along the inside of the hulls, as well as the outside, deliberately to suit paddling as occasion demanded – they were, in fact, combination sailing and paddling craft, quite unlike the historical sailing vessels of West Polynesia with their covered hulls, high sides and full platforms. Using a reconstructed Hawaiian double canoe in ocean-paddling experiments, Horvath and Finney (1976) showed that a pace of slightly more than 3 knots could be sustained comfortably for 8-hour stints over several days, enabling progress of about 50 km. per day, and more if there were several shifts of paddlers available. Such a facility provided the means to cross the Doldrums quite easily and to maintain progress through other calms and light airs.

Outriggers, as Anderson notes (p. 39), are usually faster than double canoes. They are both lighter and more seaworthy. Primitive oceanic spritsails enabled them to gain some speed from following winds. They were designed to sail with maximum stability when exploiting fast warm currents. They accommodated the different sailing strategies chosen when the largest and best resourced uninhabited islands, which could be reached by fast warm currents, were targets for settlement.

In Eastern Polynesia the capacity of the early double-outriggers with an oceanic spritsail to sail before a following wind was sacrificed to gain a better capacity for coping with light variable winds. The greater stability and seaworthiness of the early double-outriggers was sacrificed to gain more manoeuvrability and some ability to sail to windward. The lighter design of the early outriggers gave way to the increased size and greater carrying capacity of the double-hulled canoe – able to carry heavy cargoes and to carry up to 200 people in a migration. Our discussion of the migrations led by Kahukura within the Pacific in Chapter 18 documents the advantage of such a carrying capacity.

In place of the fast long-distance current-based voyaging of first- and second-wave explorers and migrants, the settlement of Eastern Polynesia probably involved a sequence of inter-archipelago migrations. For attaining speed, managing sail had become as important as or more important than exploiting currents. But exploiting currents must still have been important in tropical Polynesia. The changes in the direction of trade winds and currents in the central and eastern Pacific, induced by strong ENSO events, are believed to have assisted west–east migration and trading ventures.

As we shall see in Part II, the great voyaging and migrational activity in tropical Polynesia during the Medieval Climatic Optimum was driven largely by El Niño-induced drought and famine and/or associated conflict over land and resources. But the warm global climate favoured voyaging in this period as it had done in the preceding period of Polynesian exploration from about AD 650 to 1100. The development of specialized canoes to meet the upsurge in activity in the Medieval Climatic Optimum reflects denser settlement patterns, increased levels of migration and more specialized sailing requirements within Eastern Polynesia.

Starvation and conflict in the Medieval Climatic Optimum drove Eastern Polynesian migrations as far south as New Zealand. There can be little doubt as to the capability of the Eastern Polynesian double-canoes for handling the distances involved and little doubt as to the skills of the navigators who sailed them. The navigators who led the *Heke*, the last migration fleet to reach New Zealand before the Little Ice Age, were able to exploit wind power so effectively that, tradition reports, the *Takitimu* because of bad weather took 11 days to reach New Zealand from Rarotonga, though the journey was expected to take only 9! [5].

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Chapter 10
Studying the History of Spice Island Migration Through Cultural Diffusion

The Value of Consilient Evidence

Abstract One way of studying ancient migration paths and migration sequence is by considering the diffusion and evolution of technologies (material culture) and of cultural and spiritual beliefs and practices (non-material culture). The study of both can be difficult because of the cumulative effects of later migrations overlaying and so distorting or destroying earlier cultural practices. Yet, as this chapter demonstrates, even though throughout the Pacific earlier cultures were often overlaid by the cultures of later migrants, vestiges of earlier cultures or fragments of earlier traditions often survive to cast light on earlier migration history and to reflect the different origins and culture of earlier migrants. The persistence of a Lapita matrilineal social structure in New Zealand, with land ownership by matrilineal descent, is a good example. The preservation in Hawaii of place names derived from the Spice Islands and Spice Island region similarly harks back to a Spice Island origin for the earliest settlers in Hawaii.

Keywords Cultural diffusion · Cultural overlay · New Zealand · Hawaii · Cultural vestiges

10.1 Introduction

One way of studying ancient migration paths and migration sequence is by considering the diffusion and evolution of technologies (material culture) and of cultural and spiritual beliefs and practices (non-material culture). The study of both can be difficult because of the cumulative effects of later migrations overlaying and so changing, distorting or destroying earlier cultural practices. The intensification of voyaging and migration within tropical Polynesia in the Medieval Climatic Optimum (c. AD 1100–1400) led to significant cultural change and to the loss of local traditions, knowledge and cultural practices especially in islands subject to invasion and conquest. Hawaii and Easter Island, as we shall see in Chapters 16 and 19, are examples of cultures, long preserved in distant and isolated islands, being submerged by the cultural prerogatives of medieval migrants or conquerors.

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In New Zealand where there was a substantial land area and, as we shall see in Part II, also high populations at the beginning of the Medieval Climatic Optimum, one would not have expected the small number of medieval migrants that arrived in this warm period to subvert local traditions and practices. That they did so in many ways was due to the survival advantage of the horticultural skills and practices the migrants brought with them from Eastern Polynesia. Their choice of agricultural land for settlement, their clearing of this land to plant kumara and other tropical vegetables and their storage of harvests as an insurance against starvation brought with them such an advantage in countering famine in the Little Ice Age, the intense cold period that followed the Medieval Climatic Optimum, that many elements of their material culture were rapidly adopted by the indigenous peoples.

Yet even though throughout the Pacific earlier cultures may have been overlaid by the culture or cultures of later migrants, often vestiges of the earlier cultures or fragments of earlier traditions survive to cast light on an earlier migration history and reflect the different origins and culture of the earlier inhabitants. Edwin Burrows's compilation of cultural patterns from Central [Eastern] and Western Polynesia [1], for example, suggests a longer and more complex migration history for New Zealand than is allowed for by archaeologists who limit New Zealand's history to the last 800 or 900 years and see medieval Eastern Polynesia as the only source for genetic, technological and cultural input. It is clear from Burrows' data that culturally and technologically New Zealand is closer than any island in Eastern Polynesia to Western Polynesia. Burrows' detailed analysis places New Zealand 11th on a list of 20 Polynesian islands in sharing Western Polynesian cultural traits. New Zealand possesses eight times the number of western cultural traits seen in the Tuamotus, Hawaii and the Society Islands. It is only tenth on the list in its possession of Eastern Polynesian cultural traits, having only 68% of those in Tahiti. The items studied by Edwin Burrows are wide-ranging. They include kinship terms, musical instruments, outrigger booms, rounded house ends, the shape of canoe hulls, lateen sail versus spritsail, presence or absence of king-posts, direct versus indirect outrigger attachment, methods for making felt cloth, tanged versus tangless stone axes, month names, brother–sister avoidance and so on. New Zealand stands between the two worlds of Western and Eastern Polynesia, possibly reflecting a shared Lapita origin with Samoa and Tonga as well as cultural acquisitions from Eastern Polynesian migrants after about AD 1200. It has indirect outrigger attachment with three booms, as in Tonga and Samoa, unlike the mixed attachment and two booms found in Tahiti. In mythology it possesses ancient totemic creation myths, found in Western Polynesia, though it also has myths that involve the purposeful creation of man by a parentless creator, the form dominant in Eastern Polynesia.

The cultural differences between New Zealand and Eastern Polynesia shown in the chart we have made from Burrows' data (Fig.10.1) could be attributed to later independent evolution in Eastern Polynesia, during the Little Ice Age, which an isolated New Zealand did not share. But an alternative explanation is supported by tradition: a long indigenous prehistory for Maori in New Zealand and a long history of early migrations to New Zealand from the Spice Islands, and possibly from other Lapita colonies, prior to the arrival of medieval migrations to New Zealand

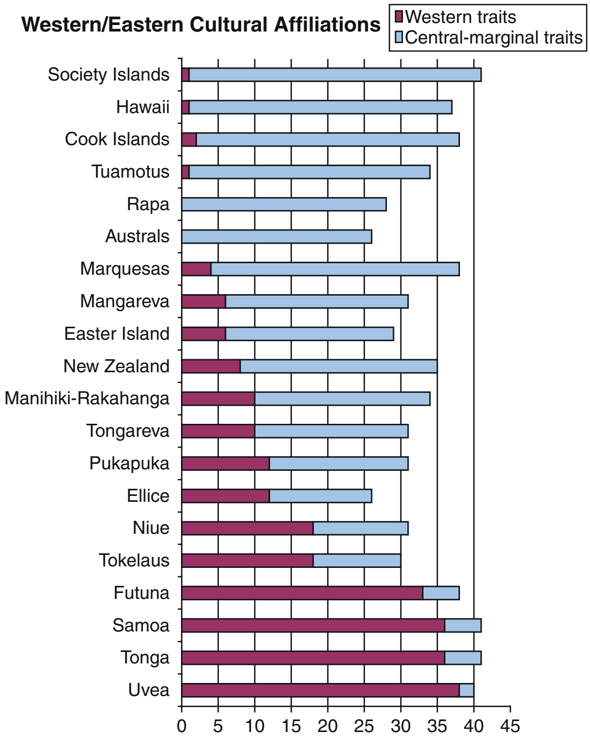

Fig. 10.1 A chart based on Edwin Burrows' analysis of the distribution of western and eastern cultural traits in Polynesia

from Eastern Polynesia. This interpretation is supported by traditional histories and genealogies that detail much of that long prior migration history. Evidence for this interpretation will be explored in Parts II and III along with a study of the vestigial survival in New Zealand, and the far more complete survival in the more isolated Chatham Islands, of ancient totemic myths and practices that can be thought of as having been originally part of the Lapita cultural complex. Analysis of these cultural survivals, we shall show, strongly supports our case for a Lapita-age first settlement of New Zealand

This chapter suggests some of the ways in which evidence from other domains – cultural, linguistic and anthropological – and evidence from traditional histories can enrich and reinforce the archaeological and scientific evidence which underpin our study of the peopling of the Pacific.

An example of the survival in New Zealand of elements of material culture with a Spice Island origin can be found, for example, in New Zealand *pa* (defensive forts or settlements). Specific constructional details – the shutting devices for gates, the kind of fighting stages built, the use of triple palisades and ditches and even the grotesque carving of palisade posts – link New Zealand pa with those from the Spice Island region (see Chapter 13.) These links are more striking because, although late settlement theorists believe Eastern Polynesia to be the sole source of Maori material culture, it is claimed that at the time of the medieval migrations to New Zealand from Eastern Polynesia, pa were not a part of Eastern Polynesian material culture. (References to pa in the tradition of Uenuku's battle with Tawheta in Chapter 18 appear to contradict this claim but may represent a Maori localizing of a Tahitian tradition.) New Zealand indigenous traditions record pa in New Zealand hundreds of years before the medieval Eastern Polynesian migrations took place (see, for example, the pa attributed to the Eastern Polynesian navigator Toi in Chapter 16).

Another example of the preservation of material cultural elements in an early colony originating in the Spice Islands is the strong link that Haddon and Hornell [2] see between the canoes of Hawaii and "proto-Polynesian" canoes of Island Southeast Asia. So strong do they consider this link that they endorse the traditional claims that Hawaii was settled from Island Southeast Asia through Micronesia and go so far as to suggest that Eastern Polynesia may have been settled via Hawaii.

But there is cultural as well as material evidence for a Spice Island Polynesian homeland for New Zealand. The persistence in New Zealand, for example, of Lapita matrilineal and matrilocal social structures, contrasts with their displacement in Eastern Polynesia during the Medieval Climatic Optimum when increased conflict over land and resources led to the seizure of land by conquest rather than its transmission through maternal lines.

It is far from unreasonable to argue that migration history in the Pacific is reflected in the conservative retention of concepts, myths and beliefs, social customs and social structures in remote isolated early colonies such as those of New Zealand, Hawaii and the Chatham Islands and their displacement or evolution in Eastern Polynesian colonies which were settled far later and were more open to influences from other cultures and regions. The traditions that record Rauru's visit to New Guinea to secure a special variety of yam and the defeated Tangiia's visit to Island Southeast Asia during the Medieval Climatic Optimum (see Chapter 19) suggest a voyaging frequency and range that opened Eastern Polynesia to cultural influences from other regions. Tradition records, for example, that Tangiia brought back new musical instruments and new dances from Island Southeast Asia.

The evolution of complex hierarchical societies in horticulturally based tropical Polynesia can be associated with evolutions in both material culture and non-material culture that in many cases were not passed on to New Zealand tribes by Eastern Polynesian medieval migrants. That New Zealand was resistant to Eastern Polynesian influences in some areas can be explained by its having a social conservatism associated with a long anterior history in New Zealand – a prehistory that, as we shall show in Part II, possibly predated the settlement of Eastern Polynesia by 1,500–1,900 years.

10.2 The Preservation of Spice Island Matrilineal and Matrilocal Social Structures in New Zealand

Linguistic evidence for the persistence of a matriarchal and matrilocal social structure in New Zealand can be seen from Burrows' list of kinship terms. New Zealand, for example, has kinship terms for mother's brother, father's sister, brother's child and sister's child that are absent in Eastern Polynesia, though they have survived in the Lapita colonies of Western Polynesia. Burrows' list of the cultural traits that New Zealand shared with Western Polynesia is scarcely surprising if New Zealand, like Western Polynesia, was settled directly from the Spice Islands before 1000 BC. By contrast, in the light of a claimed late settlement for New Zealand from Eastern Polynesia, this list of shared cultural traits appears anomalous.

For a maritime trading people, to defend such a rich possession as the Spice Islands must have posed enormous problems and goes far to explain why the ancestral Spice Island culture was matrilineal and matrilocal. Traders would be away for long periods at sea. Jealous neighbours must have attempted to seize the Spice Islands many times in the 500 years from the first archaeological evidence we have of cloves being traded internationally from the Spice Islands to Terqa, nearly 4,000 years ago, to the possibly forced migrations of the so-called Lapita peoples into the Bismarcks and Solomons 200 years later.

If New Zealand was a Lapita-age colony, it is not surprising that, as we shall see in Chapter 16, Maui the Navigator found a chieftainess at Orokoroko, Palliser Bay in the North Island of New Zealand, for Per Hage suggests that Lapita society was matrilineal: "We conclude, on the basis of historical-linguistic, ethnographic and cross-cultural evidence, that descent in Proto Oceanic society was matrilineal and residence matrilocal or matri-avunculocal" [3].

There is indeed strong evidence for the persistence of these Lapita social structures in New Zealand 1,300 years after Maui's visit. It could be claimed that the social history of prehistoric New Zealand was shaped by the premise that, although chiefly power might be passed from father to son, land rights were by matrilineal descent. Men arriving in New Zealand in migrating canoes sought *tangata whenua* (indigenous) wives, not just because there were fewer women than men on migration canoes, and not merely to protect themselves against attack and extinction when their numbers were small, through forming tribal alliances through marriage. Arriving in small numbers, migrants were unable to seize land by conquest. With land rights in New Zealand based on matrilineal descent, the only way for them to ensure the land rights of their descendants was through taking preferably high-status indigenous wives and securing the future of their line through their wife's mana (prestige).

Per Hage, studying the Austronesian matrilineal heritage of Polynesians, shows how over time the ancient pattern of matrilineal land inheritance in tropical Polynesia was overlaid by a new emphasis on warrior status and conquest of land through warfare. This seems especially to have been the case during the long period of conflict over land and resources during and after the Medieval Climatic Optimum. But even in tropical Polynesia the pattern of marriage alliances between the conquerors and high status women amongst the defeated suggests both the matrilineal origins of tropical Polynesian societies and the persisting influence of the matrilineal social structure when it came to confirming the land rights of conquerors.

Late Eastern Polynesian migrants brought the changing emphasis on warrior status and land rights by conquest with them to New Zealand. The clash between the indigenous cultural patterns and those imported from Eastern Polynesia is perhaps nowhere more obvious than in the story of Tamatea-ariki-nui, Captain of the *Takitimu* canoe. This canoe belonged to the last migration fleet to reach New Zealand. There were no women aboard this sacred canoe, whose role was to bring an ark of spiritual resources to New Zealand, both in the sacred objects and god-sticks carried aboard and in the persons of the three powerful priests chosen as navigators for the voyage and entrusted with the task of setting up three *whare wananga*, or schools of learning, in the new land, to ensure the handing on of traditional knowledge to their descendants. With women forbidden a place on this sacred canoe, the men aboard the *Takitimu* had no alternative but to choose wives from amongst the indigenous peoples.

The Captain, Tamatea-ariki-nui, familiar with the old matrilineal and matrilocal patterns, effectively superseded in Tahiti, appropriately married a chieftainess, the leader of her tribe, seeking through marriage to her to secure her mana and land rights for his children. What followed for Tamatea was a form of personal disintegration. He could not survive the loss of role, rights and status he had held as a male chief in Tahiti. He found he had moved into a world where he felt there was no place for him, no role as husband to the chieftainess that was comparable in status or power with the role he had held as a chief in Tahiti. His loss of mana induced what might be described as a psychosomatic suicide. He stayed alive just long enough to see his son born, his line secured through his wife's mana, and then died.

10.3 Studying Prehistory when there is a Paucity or Absence of Material Evidence

In places such as New Zealand and Hawaii, where tectonic activity, recurrent tsunamis and erosion can so readily destroy or bury early material evidence, study of non-material evidence may well be the most reliable way of documenting prehistory. The lack of material evidence, especially for the very early settlements of both New Zealand and Hawaii, recorded in traditional histories, is a problem. But the lack of material evidence, in fact, poses problems for most of Polynesia. Patrick Kirch and Roger Green note that "it is sobering to know that fully 80 percent of the reconstructed Ancestral Polynesian artifact array is missing from our archaeological assemblages" [4]. In Part II we seek new ways of uncovering the long prehistory we claim for New Zealand. We undertake a long and complex study of New Zealand's early prehistory and palaeodemography using new approaches to the study of existing material evidence and non-material evidence. To suggest the possibilities inherent in these new approaches, we make Hawaii our focus in the remaining part of this chapter and suggest ways of seeking evidence from both material and non-material sources for both the first- and second-wave Spice Island colonizations of Hawaii recorded in oral tradition.

10.4 The Early Migration History of Hawaii

Like New Zealand, Hawaii, as one of the three apices of the Polynesian triangle, is seen as being remote and inaccessible from Eastern Polynesia. But in the earliest phase of the settlement of the Pacific, sailing from the Spice Islands to the Hawaiian archipelago through Micronesia avoided the problems of west–east sailing and crossing the Doldrums that confronted later colonizers from the southern Pacific. Sailing north from Halmahera through Micronesia, exploiting the Kuro Shio Current and then following the current towards Hawaii avoided the contrary trade winds below it. The southerly margin of the Kuro Shio Current turns towards the Hawaiian Group as it approaches it. Though this route may seem to be very long, it is surprisingly direct. It is, in fact, only about 20% longer than the distance from Halmahera to Samoa and very much shorter than any other route to Hawaii from the Spice Islands. Hawaii possesses the largest land area in the Pacific after New Zealand, the Bismarcks, Solomons, New Caledonia and Fiji (all save New Zealand recognized as Lapita settlements). Hawaii has wonderfully fertile soils and the capacity to support big populations. And like New Zealand it can be reached by exploiting a strong West Pacific Warm Pool current that provides a rapid passage. Following the Kuro Shio Current a little further east and then sailing directly south would take a canoe to the Marquesas, where Lapita pots have been found, their clay sourced to Fiji [5]. For explorers the return voyage from both the Marquesas and Hawaii could use the trade winds that flow from east to west just above and below the equator.

Apart from Irapanga's migration, for which there is genealogical evidence from a major Rarotongan line (see Appendix 1), the timing of the early migrations to Hawaii recorded in Maori tradition is difficult to establish. The assumption by modern prehistorians that Hawaii was initially settled from Eastern Polynesia has led prehistorians in the last decade to argue for increasingly late first settlement dates. Athens et al. [6], for example, note

> The chronology of Polynesian settlement of Hawaii is a hotly debated topic with some investigators suggesting settlement occurred as early as the first century AD (Hunt and Holsen, 1991). Kirch's standard textbook on Hawaiian archaeology cites a date of AD 300 (Kirch, 1985: 58, 68), and he more recently (2000: 291–292) suggests a range between AD 300 and 600. However, we see the chronological data supporting a settlement range of AD 700–800 (Athens, 1997; Masse and Tuggle, 1998; Tuggle and Spriggs, 2000).

For many archaeologists the assumption that Hawaii can only have been colonized from Eastern Polynesia generates a reluctance to consider inconvenient early evidence. Controversy over the issue of first settlement is generated not just by the not surprising absence of early archaeological evidence but from the felt need to establish a date for first settlement that is consistent with accepted late dates for the settlement of Eastern Polynesia. As we saw in Chapter 6, the appearance of Micronesian and Hawaiian-style single-piece curved shell fishhooks in southern California before 1000 BC has been dismissed by archaeologists as evidence for technological diffusion from Polynesia because the dates involved are so much earlier than those for the settlement of Eastern Polynesia, which is seen as the only possible source for such a diffusion. Similarly when Eastern Polynesia is seen as the only possible source for migrations to Hawaii, conceivable dates for the first settlement of Hawaii are severely constrained. Unfortunately it may not be easy to find unassailable archaeological evidence to challenge this constraint. As Terry Hunt and Robert Holsen [7] explain,

> the earliest sites in Hawai'i are those that have had the most time for destruction by nature and the activities of prehistoric and modern people, and for deep burial by colluvial and alluvial sedimentation. Finding and dating early occupations in Hawaii is the problem of sampling the rarest phenomena in a population. Probability theory states that rarest phenomena are correspondingly difficult to encounter in samples, especially in relatively small ones. . .Furthermore, the samples used from the archaeology of Hawai'i are far from representative. The bulk of field work today is contract archaeology, conducted primarily in leeward zones—environments that might not, in all cases, have been settled until somewhat later than well-watered windward areas. . .in spite of the real potential for erroneously early dates, we must be careful that current predilections about what is "too early" do not seriously bias our interpretation.

The volcanic nature of Hawaii and its vulnerability to tsunamis and cyclones decreases the likelihood of finding evidence from early coastal sites. One would expect too a discrepancy in time between the arrival of the first colonists and the first discernible archaeological footprint for this arrival. We have seen from Palau a 2,300-year gap between the dating for the first palynological evidence of disturbance and first archaeological evidence of settlement. Tradition suggests the possibility of multiple early migrations to Hawaii and so of small settlements strung out through the Hawaiian archipelago, each separate settlement requiring time for a recognizable archaeological footprint to be generated. The danger of extinctions or near-extinctions for isolated early groups while their numbers are small is also relevant in terms of the earliest archaeological evidence we can expect to find in the Hawaiian archipelago. The early migration history of Hawaii may indeed be easier to infer from evidence preserved in oral traditions than from artefactual evidence.

As we saw in Chapter 5, traditional accounts preserved in New Zealand suggest a first-wave Spice Island discovery of Hawaii by Tama-rereti and early migrations to Hawaii from the Spice Islands. That Hawaii was settled before the cold period of 1000 BC is supported, we have suggested, by the finding of Hawaiian-style single-piece curved shell fishhooks in southern California dated to before 1000 BC. Tradition also records the visit by the second-wave explorer, Maui the Navigator, to Hawaii (in about AD 100 by our reckoning) following his visit to New Zealand. The fact that Maui is recorded as landing at Mahitahi (Bruce Bay) on the west coast of the South Island of New Zealand, where the East Australian Current would have taken him, establishes that second-wave explorers, like first-wave explorers before them, followed the sailing and exploring strategy of following fast warm currents flowing out from the West Pacific Warm Pool. That Maui followed sailing instructions to New Zealand probably handed down from first-wave explorers and voyaged to Hawaii immediately afterwards suggests he also had access to sailing instructions for that voyage and that he would have followed the Kuro Shio Current to Hawaii as he followed the East Australian Current to New Zealand. It is unclear whether descendants of Maui migrated over the centuries to Hawaii to claim land rights in his name, as traditions show them to have done in New Zealand till the time of Rakaihautu and even down to the time of the *Heke*. What we do know is that tradition records that Irapanga led a fleet of six canoes to Hawaii (in about AD 460 by the chronology we propose in Chapter 19). The Rarotongan line offered in Appendix 1 shows that Irapanga at least was a descendant of Maui the Navigator.

Southern migrations to Hawaii, established in Chapter 19 from a solar eclipse as having taken place by AD 1104, led to the overlaying of earlier Hawaiian genealogies and the consequent loss of much of the earlier history of the archipelago. The Tahitian genealogies that overlaid Hawaiian traditions go back to Wakea, an ancestor in many Eastern Polynesian lines. Abraham Fornander dates Wakea from imposed Tahitian lines in Hawaii to the period 230 BC–AD 160 [8]. A more precise dating for Wakea has recently been suggested by W.B. Masse who claims that "legends surrounding the progenitor Hawaiian chief Wakea (wa-ke-a, 'the sparkling period') encode a remarkable red-tailed comet in 178 A.D. along with a spectacular supernova in 185 A.D. near Alpha and Beta Centauri" [9]. Both Fornander's wide dates and Masse's more precise dates correspond to the second wave of Pacific explorations and colonizations made possible by a global return to warm conditions after 400 BC.

If, as Fornander says, Wakea was an ancestor in many Eastern Polynesian lines, he may well have been a Spice Island second-wave explorer and/or migration leader. Whether he led a migration fleet to Hawaii, however, is not clear. For the imposition of Tahitian history on Hawaii at the time of Tahitian migrations in and after 1096 may have obliterated the early history of Hawaii itself, with the genealogies of the Tahitian invading chiefs replacing the Hawaiian genealogies that enshrined lines from their own founding chiefs. The early history recorded in the Tahitian genealogies may have taken place in the Spice Islands or Spice Island region or in Western Polynesia rather than in Hawaii. But although the Tahitian genealogies preserved in Hawaii may not record early Hawaiian history, it is nonetheless possible that if Wakea was a famous second-wave navigator and explorer he might well have led a migration to Hawaii from the Spice Islands in the period AD 178–185. And it may have been the preservation of this traditional knowledge in Tahiti that a thousand years later led Tahitian explorers to search for Hawaii in the north and, having found it, to invade and take possession of it.

H.H. Lamb, who sees the history of human migration as being inevitably tied to global warm periods, speaks of a continuing pattern of explorers discovering "new" lands that are already peopled, lands discovered and settled in an earlier warm period [10]. With reference to Wakea, Fornander notes, "it is obvious from the legends themselves that the islands now held by the Polynesians were already peopled in the time of Wakea, and that by people of his own race and kindred" [11]. We would sharpen this statement by saying that tradition supports the idea that second-wave colonists found the descendants of first-wave settlers already established in the islands to which their ancestors had earlier migrated by following fast warm currents from the Spice Islands. Fornander stresses that second-wave explorers such as Wakea found the descendants of earlier Polynesian migrants already living in the lands they re-discovered. New Zealand traditions record that the second-wave explorer Maui the Navigator met with the descendants of first-wave settlers in New Zealand.

Turning from traditional to material evidence, Fornander supplies appropriately stratified skeletal evidence for the existence of very early settlers in Hawaii:

> Geologically speaking, the leeward islands are the oldest of the group, but both on Oahu and on Molokai human remains have been found imbedded in lava flows of undoubted antiquity, and of whose occurrence no vestige of remembrance remains in the Hawaiian folklore.
>
> In 1822 the first wells were dug in the city of Honolulu. They passed through some eight or ten feet of surface loam and underlying volcanic sand, when a coral bed of some eight feet of thickness was encountered and cut through, under which the fresh water was reached. In this coral formation were found embedded a human skull and sundry human bones.
>
> In 1858, in dredging the harbour of Honolulu, island of Oahu, near the new Esplanade, after scooping up and removing the mud and sand at the bottom of the harbour, it was found that underneath this sand and mud was a pan of coral rock which it was necessary to break up and remove in order to obtain the required depth of water. This pan was of an average thickness of two feet, and beneath it was a thick couch of black volcanic sand, such as is found some four or five feet beneath the surface throughout the city, and evidently thrown out by the extinct crater of Punch-bowl-hill in some pre-traditional time. Embedded in this black sand, underneath the coral bed, was found the lower part or pointed end of an ancient spear or Oo, about three feet long; and near to it a rounded small stone, the size of a hen's egg and nearly its shape, of a red, close-grained, compact and heavy lava, such as is not found in the Punch-bowl-hill formation or its vicinity. The broken spear speaks for itself, and shows that man passed over that spot by water or by land before the formation of that coral pan which now covers the bottom of the harbour and the adjoining reefs. What purposes the stone had subserved I am not prepared to say, unless it had been used for slings and dropped by the same hand or the same generation that dropped the spear. It bears no geological relation to the black sand around it, to the coral-rock above it, or to the extinct crater one and a quarter mile inland.
>
> In 1859 Mr. R. W. Meyer of Kalae, Molokai, found in the side of a canyon on his estate – some seventy feet below the surface rim of the upper level country, and among a stratum of volcanic mud, Creccia, clay and ashes of several feet in thickness – a human skull, whose every cavity was fully and completely filled with the volcanic deposit surrounding it, as if it had been cast in a mould, evidently showing that the skull had been filled while the deposit was yet in a fluid state. As that stratum spreads over a considerable tract of land in the neighbourhood, at a varying depth beneath the surface of from ten to four hundred feet, and the valleys and gulches, which now intersect it in numerous places, were manifestly formed by erosion – perhaps in some measure also by subsequent earthquake shocks – the great age of that human vestige may be reasonably inferred [11].

Given the association between migrations and global warm periods, evidence of a severe cold period between 1000 and 400 BC and traditional evidence that second-wave explorers found the descendants of earlier peoples already settled in Hawaii as in New Zealand, it is clear that these peoples must have settled there prior to 1000 BC and that the skulls buried under coral and volcanic deposits in several locations may have belonged to Lapita age or, given the stratigraphy, to even earlier explorers or migrants or accidental voyagers.

10.5 Studies with an Illuminating Singular Focus

In circumstances such as we find in Hawaii and New Zealand, whose erosion and tectonic histories suggest that early material evidence will be deep-buried, absent or unlikely ever to be retrieved, studies with an illuminating singular focus can be especially helpful for verifying information recorded in oral traditions. A good example is the recent work of Kenneth Collerson and Marshall Weisler [12] which authenticates Hawaiian oral histories recording voyages during the medieval warm period of several thousand kilometres from Hawaii to Tahiti and back via the Tuamotus. The authors show that the trace element and isotope chemistries of a stone adze recovered from the Tuamotu archipelago are similar to Kaho'olawe Island hawaiite in the Hawaiian Islands and that other adzes collected from the Tuamotus have sources in the Marquesas, Austral and Society Islands and the Pitcairn Group, confirming that there was widespread trade within Eastern Polynesia during the medieval warm period. The authors suggest that this trade "continued until 1450 when most voyaging ceased in eastern Polynesia". In this example a very specific focus has been used to illuminate an issue of some significance: the trading range and trading history of Eastern Polynesia during the Medieval Climatic Optimum.

Where Collerson and Weisler's study focuses on the scientific analysis of material evidence, Fornander [13] uses non-material evidence to establish a Spice Island origin for the first Hawaiians. He does so through a study which also has a singular focus: a study of place names in Hawaii which clearly originated in the Spice Island region.

A guide to migration history can often be found in place names. It is common practice for migrants to name places in a new homeland after places in the land they have left. Improbable place names like "New South Wales" and "New Zealand" have risen from the practice in recent times. Fornander establishes that a considerable number of place names from the Spice Islands and Spice Island region have been preserved in the Hawaiian archipelago. The preservation of these ancient place names not only points to a Spice Island origin for the earliest settlements in Hawaii and for second-wave Spice Island settlements which preceded the southern incursions of 1096 (see Chapter 19) but also implies a largely isolated history for Hawaii before that time. To have confirmation through Fornander's analysis of place names for early Spice Island settlement is important given the reluctance of many Pacific prehistorians to consider anything other than a late Eastern Polynesian base for Hawaiian prehistory and archaeology.

That Halmahera, other islands in the Spice Island archipelago, and some islands in Island Southeast Asia featured directly in Hawaiian ancestral history is strongly suggested by the naming of islands in the Hawaiian Group and places on those islands after islands and places in the Spice Island region.

Abraham Fornander lists 31 such namings. Most obvious is the naming of Molokai in Hawaii after Morotai, an island off the north coast of Halmahera. Oahu island in Hawaii has the same name as a state in northern Borneo. Bora-bora, one of the Society Group and Pola-pola, lands in Ewa, Oahu, in Kula, Molokai, and in Llahaina, Maui of the Hawaiian Group, are named after Pulo-Pora, an island off the coast of Menangkabau in Sumatra. Namuka, one of the Tonga Islands, and also one of the Fiji Group, refers to Namusa, one of the Mengites Group in the Spice Islands. Kauai, one of the Hawaiian Group, is named after Tawai, one of the Batchian islands, west of Gilolo in the Spice Islands. Hawaii itself is named after the ancestral Hawaiki, which Fornander sees as a variant of the name Java, the second of the Sunda Islands. Both Fornander and Smith believed Savaii in Samoa and Hawaii to be named after Java, and the general name of the Polynesian homeland, Hawaiki, also to derive from Java. It is possible, however, that the island of Java was named from Hawa, an ancient name for the Spice Islands, perhaps the original Hawaiki. Indeed Hawa is still the Bugis name for the Spice Islands. Halmahera's ancient name "Gilolo" occurs in "ancient Hawaiian chants, legends, and prayers" (as in O-lolo-I-mehani which translates as "Gilolo the red" and O-pae-Lolo which literally means "the Lolo group").

The 31 place names in Hawaii which, Fornander shows, can be sourced to the Spice Island region add weight to the suggestion that, as oral traditions claim, Hawaii over a period of 1,500 years was colonized via Micronesia directly from the Spice Islands, Wallacea or the Indonesian archipelago rather than indirectly from a later settled Eastern Polynesia.

The Lapita colonies in Western Polynesia and islands colonized from them also carry names from Island Southeast Asia. For example, the Tongans believed that mankind came from Bolotu, the principal residence of the gods, placed in the Northwest. Fornander suggests that Bolotu is a version of Gilolo which, as we have seen, is an early name for Halmahera.

It is not surprising that if Hawaii was settled directly from the Spice Islands or Wallacea that place names from the area were so well preserved in Hawaii. Because of its isolation – specifically due to the late settlement of Eastern Polynesia and to the difficulty of accessing Hawaii from Eastern Polynesia – its migration history is unusually simple. If, as we suggest, Hawaii had a Lapita-age first settlement, by the time of the medieval southern incursions, it would already have had a significant population. This would have helped to preserve original place names. Maui the Navigator is recorded as having "fished up" the Hawaiian Island of Maui as well as the North Island of New Zealand and, as in New Zealand, he left a record of his visit to Hawaii in places named after him.

New Zealand, with its larger land area, probably attracted more migrants than Hawaii. Its complex migration history is possibly reflected in changing place names. This is illustrated in Chapter 16 in the oral record of the large number of landmarks Maui named after himself and members of his crew. Indeed there seems to have been a persistent practice in New Zealand amongst migrants, early and late, of naming landmarks after themselves. Rakaihautu, in about AD 840 by our reckoning, with his following walked the length of the South Island, naming lakes and mountains, and many generations later his descendants were still consistently naming mountains after themselves. Herries Beattie connects no fewer than 26 out of 44 descendants of Rakaihautu in one genealogy with place names in the South Island [14]. Kupe – possibly the first Eastern Polynesian explorer to reach New Zealand – named many places in New Zealand: Jeff Evans lists 30 [15]. Like Maui, Kupe left migrants to support his rights to a land, which as the first Eastern Polynesian explorer to visit New Zealand, he claimed to have discovered. Kupe's grandson, Nuku-tawhiti, is said to have joined the colony Kupe left behind him at Hokianga, just as hundreds of years earlier descendants of Maui came to take up land rights they believed they had inherited from Maui. Even Turi, Captain of the *Aotea* canoe of the *Heke*, the last migration to reach New Zealand, claimed his right to land in the North Island as a descendant of Maui. He and his crew, along with most of the *Heke* immigrants, had no sooner landed than they set their seal on the land by naming features after themselves and their first experiences in New Zealand.

Place names in New Zealand reflect a long history of migration, the earliest names probably overlaid many times. There are a few obvious exceptions. Maui met the chieftainess at Orokoroko in Palliser Bay, a name that, as we have seen, means "the very first place", "from the very beginning", and so may be an ancient name. As may be the name Cape Te Reinga, "The Leaping Place", at the northernmost tip of the North Island. As with similar "Leaping Places" in Polynesia it is the place from which the souls of the dead set out on their journey back to the ancestral homeland of Hawaiki. For Maori the direction of the spirit leap and path is to the north rather than to the west (as in Western Polynesia and Eastern Polynesia). This New Zealand path perhaps enshrines a memory of an ancient migration voyage from the north that must be matched by spirits in reverse in order to return to their spirit home. That the name and concept of "The Leaping Place" are of great antiquity is suggested by their occurrence amongst aborigines along the east coast of Australia [16]. There, as in New Zealand, the spirits of the dead travel to the "Leaping Place" in order to find the path to their spirit home in the north. One can only conclude that both the name and concept must be older than the colonization of the Pacific and to have reached both Australian aborigines and Polynesians through diffusion from the Spice Islands – very long ago in the case of the Australian aborigines. Or that a migration from New Zealand to Ulimaroa (Australia), known in Captain Cook's time to the Bay of Island Maori, had a long-term influence on some aboriginal tribes of the east coast of Australia and led to their adoption of this cultural belief.

10.6 Part I: A Summary

In Part I we propose a new paradigm for the rapid early settlement of the largest and best uninhabited islands in the Pacific and Indian Oceans. This paradigm has an oceanographic base in the history of changes within the West Pacific Warm Pool and in the ocean paths provided by three of its four major currents. And it has a global climate modifier, warm global climate periods fundamentally determining the periods in which transoceanic current-driven voyaging in the Pacific and Indian Oceans was feasible and practised. We show that by using the sailing and exploration strategy of following powerful warm currents flowing out of the West Pacific Warm Pool, Spice Island mariners reached and/or established settlements in Micronesia and southern Japan to the north, Hawaii and America in the east and Madagascar and east Africa to the west and that they did so before 1000 BC. In Part II we shall provide evidence that in the same period they also discovered and settled New Zealand to the south. We show in Part I that after about 600 years and perhaps 25 generations, the same feats were repeated by descendants of the first explorers and colonists. These repeated maritime feats fulfil the predictions of our paradigm for two waves of exploration and migration separated, between 1000 and 400 BC, by the coldest global climate period in 6,000 years. In both eras we show the fulfilling of the prediction, implicit in our paradigm, that Spice Island mariners would have reached and/or settled lands at the furthest limits to which fast warm currents flowing out from the West Pacific Warm Pool could have carried them.

Traditional knowledge was the mainstay of Spice Island and Polynesian societies. It provided the basis for continuity and success. Horticultural knowledge and experience stretching back thousands of years transformed the wild clove trees that still grow on Halmahera into the highly evolved clove trees that were nurtured on its five off-shore islands. Uniquely adapted to the microclimates of these five islands, these trees produced cloves with intense perfume and taste and heightened medicinal properties. Cloves provided Spice Islanders with a unique trading item whose value was so high because cloves such as these could not be grown anywhere else. Astronomical knowledge learnt from their ancestors taught Spice Islanders not only when to plant and harvest crops but how to navigate by the stars. The skills and experience learnt in their West Pacific Warm Pool voyaging nursery taught them how to build and sail stable, seaworthy double-outriggers, still used to this day in Indonesia and the Indian Ocean. There we suggest that they learnt the techniques for safely negotiating fast ocean currents that made it possible for them to become international maritime traders 6,000 years ago and that enabled them three and a half thousand years ago to colonize Madagascar, trade to the Middle East and Europe through east Africa and to reach America. With knowledge of the predictable patterned behaviour of ocean currents, Spice Island mariners could use currents to lead them to new lands and find reverse currents to take them safely home. Passing on sailing directions for the new lands to their people opened up possibilities for future colonizations.

Following powerful currents as an exploration strategy avoided the problems of west–east sailing against the trade winds and currents in the southern Pacific. This strategy made rapid exploration of parts of the vast Pacific and Indian Oceans possible. The early discovery of the largest islands, Madagascar and New Zealand, and of the fertile Hawaiian Islands, provided migration targets which, in warm global periods, were sought as refuges for defeated tribes and as lands to which their discoverers' descendants migrated to claim land rights by virtue of their ancestors' discovery of them.

Traditional histories endorse the historicity of migration paths predicted by our paradigm. Tradition tells us that Maui the Navigator landed on the west coast of the South Island of New Zealand where the diverging part of the fast warm East Australian Current would have taken his canoe. Archaeological evidence shows that both first- and second-wave Spice Island explorers were carried by the Kuro Shio Current to predictable landfalls in southern California.

We have argued that the early discoveries of Madagascar, New Zealand and Hawaii were the predictable result of adopting an exploration strategy based on following the diverging edge of a strong current towards land. We have suggested that supporting evidence for a very early settlement of New Zealand can be found in the migration history of the Pacific rat and in the persistence in New Zealand of a matriarchal and matrilocal social structure of Lapita origin. We see the two combine in consilience when Maui the Navigator meets the chieftainess at Orokoroko on the site in New Zealand where a Lapita rat haplogroup was found.

In this chapter we have explored consilient evidence, suggesting methods for studying the history of Spice Island migrations and migration sequence in situations where material evidence for the early migrations recorded in traditional histories is scant or even absent. A range of means for studying migration history through the diffusion of both material and non-material culture has been proposed. We have found evidence for a Spice Island origin for New Zealand, for example, from material evidence (constructional details in New Zealand pa which link them to fortifications in the Spice Island region) and from non-material evidence (the persistence in New Zealand of matrilineal and matrilocal social structures regarded as being of Lapita origin, largely displaced in Eastern Polynesia before medieval migrations from Eastern Polynesian to New Zealand took place).

Studies with a singular focus such as Collerson and Weisler's scientific analysis of the trace elements and isotope chemistries of stone adzes enable to confirm the widespread trading within Eastern Polynesia in the medieval warm period that is recorded in tradition. Fornander's compilation of Spice Island place names preserved in Hawaii, as indicators of the origins of early migrations to Hawaii, similarly provides robust confirmation for information recorded in oral traditions.

In this chapter we have sketched a range of possibilities for studying early migration history and sequence in circumstances where the paucity of archaeological evidence is constraining. Some of these approaches are explored in depth in Parts II and III. In Part II we attempt to establish our claim for a Lapita-age first settlement of New Zealand through both archaeological (material) and non-material means. Indeed, our approach for supporting this claim is divided almost equally between evidence from material and non-material sources: for example from mathematical analysis of data from field archaeology, studying traditional histories with cultural sensitivity and a scientific awareness and studying the historical implications of the diffusion and evolution over time of Spice Island myths and rituals in the Pacific. These approaches cumulatively enrich understanding and in complementary ways endorse our claim for a Lapita-age first settlement of New Zealand. In Part III we sketch a chronology for Polynesian prehistory through exploiting interfaces between Polynesian genealogies and western chronology provided by astronomical and climate proxy data which in some cases enable us to precisely date events recorded in traditional histories.

Where in Part I we sought evidence for the fulfilment of what some would see as the most extreme prediction implicit in our paradigm – that both first- and second-wave explorers reached America by following the Kuro Shio Current to its limit in the northern Pacific – in Part II we set out to establish evidence for what we feel is another test case for our paradigm: a Lapita-age first settlement of New Zealand.

Clear archaeological evidence for early Spice Island contact with southern California, following the Kuro Shio Current, and for transoceanic trading with east Africa via the Cinnamon Route creates oceanographic, geographic and chronological contexts in which a Lapita-age first settlement of New Zealand can be seen as likely. The distances traversed and the fact that these oceanic feats were performed before 1000 BC reduce our perception of the scale of the maritime feat involved in the early Spice Island discovery and settlement of New Zealand, which was significantly closer to the Spice Islands than either America or Africa. Of course, it is not just a matter of the distances involved that determines the degree of difficulty. How quickly and easily a distance can be traversed is relevant. History suggests that it was simpler for Spice Island mariners to follow a powerful warm current over more than 11,000 km to reach southern California than it was to sail against the contrary winds and currents of the southern Pacific over the 1,200 km needed to reach Eastern Polynesia from Western Polynesia. The difficulty with establishing a sound case for a Lapita-age first settlement of New Zealand – our task in Parts II and III – is not a matter of maritime difficulty. It arises from the fact that a case for a very early settlement has to be made in the face of the now entrenched belief that first settlement took place no more than 800 years ago. Neglected oral histories have to be resurrected and the palaeodemography and prehistory of New Zealand have to be effectively rewritten before our case can be clearly established.

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Part II
Evidence for a Lapita-Age First Settlement of New Zealand

Chapter 11
Challenging a Late First Settlement Date for New Zealand

Abstract Rates of population change, estimates of founder populations and first settlement dates are all open to dispute and can be chosen consciously or unconsciously in accordance with a demographer's beliefs. Each such package of choices, and most notably the first settlement date, carries demographic implications and consequences. We consider the demographic implications of a now widely accepted first settlement date for New Zealand of AD 1200 to illustrate the problems and absurdities that can arise when an inappropriate date for first settlement is chosen. A numerical exploration of a late date for the first settlement of New Zealand in relation to the population capacity of New Zealand's 7,000 pa (hill-forts) and in relation to population decline rates elsewhere in the world in the Little Ice Age effectively provides a reductio ad absurdum argument against the theory of a late first settlement for New Zealand.

Keywords New Zealand · Prehistoric growth rate · Early settlement · Global population decline · Pa capacity · Little Ice Age

11.1 Introduction

A computer simulation of possible voyaging routes from New Caledonia to New Zealand, carried out by Auckland archaeologist Geoffrey Irwin in 1992, found it to be no more difficult for Lapita colonists to "reach New Zealand from Eastern Melanesia" than to make the crossing from Eastern Melanesia to Fiji and West Polynesia [1], as they are known to have done in Lapita times. Irwin's simulation was not concerned with following fast currents and assumed a North Island landfall. Nevertheless it implies that a Lapita colonization of New Zealand was technologically feasible 3,000 years ago. Our paradigm predicts that Spice Island mariners, following a third major WPWP current, the East Australian Current, would have discovered and colonized New Zealand before 1000 BC. Evidence for Lapita-age settlements of Madagascar, Japan and Hawaii and for contact with east Africa and America before 1000 BC enhances the likelihood that Spice Island colonists would have followed the East Australian Current over the shorter distance to New Zealand.

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The existence of favourable global climate conditions 3,600–3,000 years ago further supports this possibility, as does the likely availability of El Niño northerly winds in this period able to support a fast voyage south. Anderson et al. [2] claim a peak in the frequency of ENSO events 3,400 years ago. In the exceptionally warm global conditions between 3,600 and 3,000 years ago, New Zealand, the largest uninhabited landmass in the Pacific, would have perhaps been more inviting to colonists than in any period since.

A possible Lapita-age colonization of New Zealand accords with Spice Island sailing and exploration strategies, with global climatic conditions favouring migration and with the existence of a fast ocean road from the Spice Islands to New Zealand exploiting another of the major warm currents flowing out of the WPWP. It accords too with the leap-frogging migration strategy that suggests that New Zealand as the largest Pacific archipelago would be easily discovered and an early and natural choice for a colony. Finding evidence to establish definitively that New Zealand was settled in Lapita times is nonetheless a challenge.

Study of the past climate and morphology of New Zealand makes it clear that archaeological evidence for a Lapita-age first settlement may be difficult to find. There is evidence of extreme erosion in successive warm wet periods since the Lapita era. Early estuarine and riverine landscapes dating back more than 3,000 years could lie buried under perhaps 15 m of alluvium. Coastal settlement sites of that age would have been destroyed by continuous coastal erosion, to say nothing of recorded nationwide tsunamis, estimated to occur every 500 years [3].

Searching for evidence in fields such as demography, and climatology, has yielded strong evidence for a Lapita-age first settlement.

Our argument *for* a very early first settlement of New Zealand is neither easy nor obvious. It is based on complex and sometimes indirect evidence, ranging from global climate history and statistical analysis of skeletal data, to power law analysis of pa rank size distribution curves. A combination of evidence from many fields and the development of new contexts in which to view this evidence are needed to unravel the demographic history of New Zealand on which our argument depends. In contrast, our argument *against* a late first settlement – our focus in this chapter – is simple. It requires only a reductio ad absurdum to demonstrate demographic fallacies implicit in arguments for a late first settlement. Before we can issue our challenge to a late first settlement date, however, we need to discuss some of the demographic parameters involved.

Of prime importance is the contentious issue of population growth rates. As archaeologists in the last decade have claimed increasingly later settlement dates for Eastern Polynesia and New Zealand, they have suggested correspondingly higher population growth rates. In some cases in tropical Polynesia higher rates for limited periods may be reasonable. But for New Zealand, prior to AD 1200, a distinction needs to be made between population growth rates appropriate to the settled hunter/gatherer life mode of New Zealand Maori before the introduction of the kumara (in about AD 1200 by our calculation: see Chapter 17) and the higher population growth rates possible for limited periods for the horticulturally based societies of tropical Polynesia. It is interesting that Dye and Komori's detailed study of Hawaiian demography [4] suggests a low average population growth rate over 1,400 years of only 0.25%, though Hawaii is the largest and most fertile archipelago in Eastern Polynesia and had an extensive horticultural system.

11.2 Factors Determining an Appropriate Population Growth Rate for Prehistoric New Zealand

Colonists from Eastern Polynesia reaching New Zealand after AD 1200 brought with them the kumara, tropical taro, yam and gourd. But even with a limited horticulture based on these vegetables, the late colonists would still have been fundamentally dependent on hunting, fishing and the gathering of forest foods. None of the Polynesian tropical tree staples – coconut, breadfruit, banana and tree nuts – which are easily grown and readily harvested in tropical Polynesia, could be translocated to New Zealand. And the kumara could yield only one harvest a year in New Zealand. In Polynesia it had repeated harvests because it grew there as a perennial rather than an annual.

Douglas Sutton [5] demonstrates the limited nutritional value both of forest foods and of the Polynesian cultivars introduced into New Zealand after about AD 1200. He claims, for example, that an adult would need to eat 2 kg daily of any of these cultivars to meet energy needs and he questions Houghton's opinion [6] that the prehistoric diet was "generally adequate". He relates recognized poor fertility rates for prehistoric Maori women to inadequate nutrition:

> It appears that there was a significant reduction in the availability of terrestrial and shoreline sources of protein through time. Although there were many edible indigenous plant foods, probably about 40 in total, most were small and dispersed while more important ones required lengthy detoxification processing and cooking over 12–24 hours, and offered only relatively poor food value per unit weight. Only small parts of most wild plants were edible and these were limited in their spacial distributions, concentrations and season of availability (p. 303).

Though poor nutrition and even chronic malnutrition may not have had a direct impact on female fertility, they are likely to be associated with a restrained population growth rate. Allowing for the importance of marine and estuarine resources in New Zealand and the initial abundance of seals, the giant moa and many other birds, an initial 0.5% per annum rate of population increase might have been possible. But it is unlikely that this rate could have been sustained for long for a society that till AD 1200 lacked horticulture.

Certainly the prehistoric growth rate of settled hunter/gatherers in New Zealand would be higher than that of the nomadic hunter/gatherers of prehistoric Australia, largely because Maori had a calorie-saving settled existence. Nomadic hunter/gatherers can only afford to sustain a static population growth. Because they cannot store food against the risk of scarcity, they need to maintain a population level far below the level of physical sustainability. They have to do so to protect themselves against adverse climatic events leading to food shortages and the spectre of famine.

The agricultural revolution over 10,000–20,000 years ago in the Middle East saw the development and cropping of cereals, root crops and tree crops, and the appearance of herding and animal husbandry. The capacity to follow or maintain herds and to harvest and store food crops led to higher population growth rates. Before AD 1200 the insurance of stored horticultural harvests was not available to New Zealand Maori and herd animals were notably absent. If an initial 0.5% per annum rate of population increase were possible, it is unlikely that it could have been sustained as populations reached higher levels in relation to food resources. Without food storage there was a risk of population collapse if there were serious reductions in the food supply.

If Maori had possessed the white potato from first settlement, their demographic history would have been very different. For the white potato could produce reliable harvests in cold and wet conditions and could be stored. After European settlement, the introduction of the white potato clearly helped slow a population decline which had been accelerated by introduced disease and musket warfare. If Maori had possessed the white potato in prehistoric times, higher population rates might have been possible. But Maori would still have been without the tropical tree fruits on which tropical Polynesians depended to help meet their carbohydrate needs.

Before AD 1200, before medieval migrants brought systematic horticulture to New Zealand, Maori without tropical vegetables and fruits had to depend on fern root as a staple food. Fern root was a famine crop in tropical Polynesia, eaten in times of extremity. Its major drawback as a staple food for Maori was that it seriously abraded tooth enamel. This increased the risk of tooth infection, which long term posed the risk of tooth abscesses leading to blood poisoning and early death. Through its contribution to early deaths, dependence on fern root as a carbohydrate staple would have limited the population growth rate possible in prehistoric New Zealand.

New Zealand's great advantage over tropical Polynesia was its landmass. Island Melanesia and tropical Polynesia were able to use terracing and irrigation. Tropical Polynesians dug ponds and exploited swamps to grow taro. They could grow a significant range of tropical cultivars. The horticultural systems they developed supported significant population densities. But the tropical islands were limited in size and subject to periodic El Niño-induced drought and famine and to crop damage from cyclones. Climate-caused crop loss posed a serious problem to their populations (as they have always done for horticultural societies). Once populations were high in relation to land area and once most suitable land had been exploited for horticulture, the tropical Polynesian islands were inevitably subject to conflict over land and resources and to a climate-driven boom/bust demographic cycle [7]. New Zealand's area is 15.6 times that of the Hawaiian Islands, the largest Eastern Polynesian archipelago. This allowed for internal migration when food resources grew short. The New Zealand population could be far larger before the remedy of internal migrations was replaced by the kind of conflict over land and resources that was common in tropical Polynesia during resource shortages.

The limitation in carbohydrate sources and the possibility of early adult deaths from tooth decay and blood poisoning associated with dependence on fern root as a staple food, however, both prescribed a low population growth rate for New Zealand, without the extreme fluctuations characteristic in the tropics. In New Zealand, this being so, the achievement of significant population levels implies a long demographic history and an early first settlement.

11.3 Time as the Fundamental Variable: The Demographic Implications of a 0.5% p.a. Growth Rate in Prehistoric New Zealand

Rates of population change, estimates of founder populations and first settlement dates are all open to dispute and can be chosen, consciously or unconsciously, in accordance with a demographer's beliefs. Each such package of choices, and most notably the first settlement date, carries demographic implications and consequences. To illustrate the problems and absurdities that can arise from the choice of an inappropriate date for first settlement, we focus now on the late settlement date of AD 1200, widely adopted by archaeologists following a seminal paper by Atholl Anderson in 1991 [8]. Our argument is effectively a demographic reductio ad absurdum.

For illustration we choose a 0.5% per annum rate of increase, the highest rate that might conceivably be chosen for a settled hunter/gatherer society for a limited period in advantageous circumstances. We note, however, that it is quite improbable that such a rate could be sustained over the 600-year period being considered. A simple calculation shows that even with a 0.5% rate of increase it would take 250 years for a founding population of 300 to grow to 1,000. This rate of increase is less than half the rate needed to achieve John Rutherford's estimate for the population of the North Island in 1801 of 166,000 (1.056% per annum). But it is twice the average rate of population increase estimated by Dye and Komori over 1,830 years in Hawaii (0.25% per annum).

With a first settlement in AD 1200, even with a population growth rate of 0.5% per annum, the New Zealand population at the time of Cook's visit would be only 5,150. Even the improbably high population growth rate of 0.5% per annum is clearly untenable in view of Cook's 1770 estimate of 100,000 in both islands [9].

Cook's estimate, attributed by some to Georg Forster who took part in Cook's second voyage, was based on shipboard observations together with a handful of landings and was probably not an over-estimate. (This is discussed in more detail in Chapter 13.) The historian John Rutherford proposed two estimates for the population of the North Island in 1801, one of 155,000, one of 166,000, but Dorothy Urlich considered these to be under-estimates. She suggested a figure of 175,000

[10]. Rutherford's two estimates were derived from different sources, one compiled from estimates for individual tribes and one compiled from estimates for different areas. Despite the discrepancy involved we have chosen in this and following chapters to work with the range provided by these three estimates.

An unrealistic population growth rate of 1.056% per annum, sustained improbably over 600 years, would be needed to achieve Rutherford's higher estimate of 166,000 in 1801. But even if this unrealistic growth rate were successfully defended, the late settlement theorists' problems would not end there.

The claim that there is no direct archaeological evidence for settlement in New Zealand prior to AD 1200 may technically be true, if one accepts Anderson's arguments for the dismissal of all radiocarbon dates before AD 1200 on the grounds that they offend chronometric hygiene. But it is effectively misleading. There is, in fact, compelling archaeological evidence for an early first settlement. Seven thousand Maori pa (hilltop forts) are currently listed on the New Zealand Archaeological Association's national site register (personal communication, Tony Walton, 16/2/06: the precise number is 6,956, and excludes gun-fighting pa). Maori pa are the most visible artefacts in New Zealand. While no pa may yet have been dated to before AD 1200, this is irrelevant to an argument for an early first settlement. Their evidence is implicit, not explicit. The sheer number of pa, their distribution, density and the massive labour investment they represent bespeak very high populations needed both for building and manning them. Both tradition and, as we shall see in Chapter 13, the observations of early Europeans suggest that, although, as modern analysis shows, over 50% of pa had an area of less than 2,100 m^2 [11], there were also pa that housed and defended thousands.

A peak population at the time of European contact – an essential premise for the theory of late first settlement – presupposes lower populations earlier. This intensifies the dilemma of there being too many pa for conceivable levels of population.

Consider the demographic pattern this late settlement theory entails and its consequences in relation to the number of pa. As we have suggested, an unrealistically high average growth rate of 1.056% per annum maintained over the 600 years from AD 1200 to 1801, with an effective founder population of 300, could give a population of 166,000 in 1801. Most pa are dated from about AD 1400 to AD 1700, with datings said to be evenly spaced over this time [12]. This claim is not entirely free of contention because of confusion between initial construction and later fortifications. But as the possibility of even spacing over time is the best case for late settlement theorists to adopt, we consider it first.

If, with this scenario, one-third of pa (2,319) were built and manned in the period AD 1400–1500, despite an unrealistically high population growth rate (1.056% per annum), we would have a population of only 2,454 in AD 1400, rising to 7,020 by AD 1500. This would mean that as late as AD 1500 there would be a population of fewer than 3 being defended by each of the 2,310 pa then built. At AD 1600, with a population of 20,079, still assuming that one-third (2,319) of pa were built and manned in the period AD 1500–1600, there would be fewer than 9 people defended by each pa, with only 3 warriors to defend each pa, assuming that in a very fast-growing population one-third of males were children. By 1700, with a population of 53,430, there would be 29 people defended by each pa, with 10 warriors defending them. The figures would look even more absurd if the total population capacity for pa, rather than the number of pa, were used in the calculations and a longer period of use than 100 years allowed for.

In other words, from a demographic viewpoint, the estimate of 166,000 in 1801, *conceived of as close to the maximum prehistoric population achieved in New Zealand*, is far too small to account for the 7,000 registered pa, even assuming, as we do here, that no pa built in one period was still being used in another.

If, as Aileen Fox noted, archaeological evidence suggests that most pa were occupied for several centuries [13], so that earlier pa were still being used in a later century or centuries, this would further lower already absurdly low figures.

We have considered the improbably high population growth rate of 1.056% per annum needed to reach a population of 166,000 in AD 1801 from a founding population of 300 at AD 1200. Even with a growth rate as high as this, the problem of matching conjectured populations to pa capacity is extreme. That a population growth rate of 1.056% per annum lacks feasibility can readily be illustrated by considering it in the context of world population growth rates for the period AD 1200–1800 and also in the context of the population growth rates estimated by Dye and Komori for the same period for Hawaii. Table 11.1 computes three population growth rates for a conjectured late first settlement of New Zealand in AD 1200, based on a founding population of 300, with

(i) average world population growth rates,
(ii) Dye and Komori's estimates for population growth rates for Hawaii, and
(iii) the population growth rates needed to take a founding population of 300 to 166,000 in AD 1801.

The population growth rates listed in the table refer to the preceding period.

In Table 11.1 low fluctuating population growth rates for the world and Hawaii from AD 1200 to 1800 (based on Dye and Komori's data) are in marked contrast to the continuous hypothetical high rate needed to achieve Rutherford's estimate, assuming a late settlement date for New Zealand of AD 1200. The demographic implausibility of a late settlement date for New Zealand is clear from these practical examples. The long period of negative growth rates for Hawaii during the Little Ice Age, despite its proximity to the equator, is striking.

We may need to counter the argument that Eastern Polynesian immigrants arriving in AD 1200 as first settlers would have multiplied rapidly because they had entered a pristine environment. The global and Hawaiian population growth rates in Table 11.1 reflect both the problems of El Niño-associated drought and famine in Eastern Polynesia and the global harshness of the Little Ice Age to which New Zealand, situated in the high latitudes, would have been vulnerable. The medieval migrants reaching New Zealand were far from entering a paradise. Nor, we argue, were they arriving in uninhabited islands. The demographic implausibility of a late first settlement, clear from Table 11.1 and from the problem of matching late migrant

Table 11.1 A demographic reductio ad absurdum

AD	World growth rate	Population	Hawaii growth rate	Population	Uniform growth	Population
1200	−0.01	300	0.93	300	1.056	300
1340	0.08	296	0.32	1,096	1.056	1,306
1500	0.15	336	−0.01	1,825	1.056	7,020
1600	0.07	391	−0.14	1,810	1.056	20,079
1650	0.43	404	−0.55	1,687	1.056	33,958
1700	0.26	501	0.35	1,281	1.056	57,430
1750	0.39	571	0.08	1,525	1.056	97,127
1770		617		1,550		119,847
1801		696		1,589		166,000

populations to pa capacity, shows rather that they were entering a country with a significant population and a long demographic history. A long time was needed for the development of populations by AD 1445 which were able to match pa with a total area of over 23 million m^2 (computed from just 90% of pa over 2,100 m^2 in size).

The paucity of native food plants and the fact that the fruit and nut trees that Polynesians relied on in the tropics could not grow in New Zealand meant that the horticulture introduced by the medieval migrants was mostly restricted to the four tropical vegetables they brought with them, the kumara, yam, taro and gourd, all of which had to be acclimatized to New Zealand. The descent of the Little Ice Age in about AD 1400 would have drastically reduced the harvests of all of these tropical plants.

If the medieval Eastern Polynesian migrants had arrived in a pristine uninhabited land, why would they, as a tiny population 200 years after first settlement, have begun to undertake the construction and defence of pa? And why did these pa require such extreme protection? Elsdon Best mentions pa with palisades 9 m high and ditches 7 m deep [14].

There is a striking disparity between the likely size of a population in New Zealand 600 years after a first settlement supposedly taking place in AD 1200 and the population capacity suggested by 7,000 Maori pa. Though, as we have commented, many pa were small, there were undoubtedly pa that protected and were protected by thousands. The photograph of the pa on One Tree Hill, Fig. 11.1, is one such example. Clearly if the population observed by Cook were somewhere between 617 and 1,550 (computed by Table 11.1 using world and Hawaiian population growth rates as opposed to the implausible implied growth rates for a late first settlement), Cook's estimate of 100,000 would never have been made and the Maori wars would never have been fought.

We shall argue in following chapters that the population Rutherford and Urlich estimate to be between 155,000 and 175,000 in 1801 was not a peak population descended solely from medieval Eastern Polynesian migrants and achieved after only 600 years. Rather we shall argue that it was the remnant of a much larger

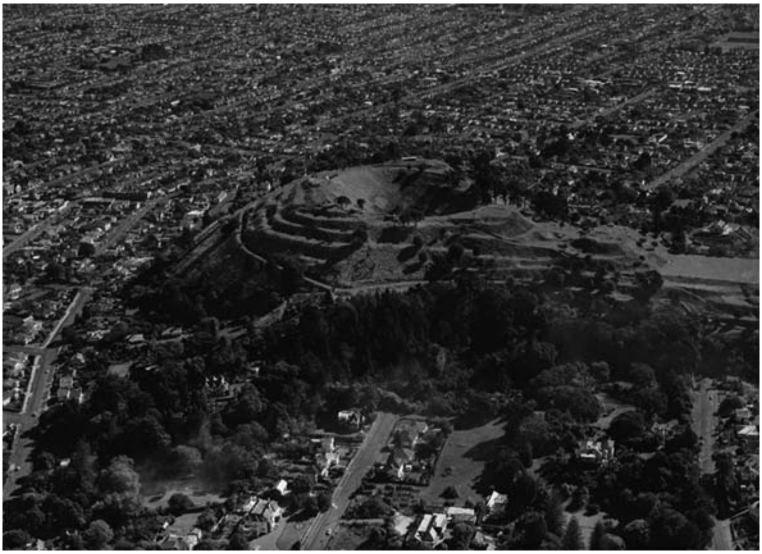

Fig. 11.1 The volcanic cone pa of Mount Eden, Auckland. Aerial view from the east showing extensive terracing, crater and strong points. Reproduced with permission from Alexander Turnbull Library, Wellington

indigenous population whose origins reached back to Lapita times. We show in following chapters that in the Little Ice Age this population along with recently arrived medieval migrants, like most of the populations in the world, suffered starvation and associated conflict over resources. The construction and defence of 7,000 pa in Little Ice Age New Zealand reflect such conflict. Extreme levels of population decline are clear from the skeletal evidence discussed in Chapter 14. Rapidly rising populations are essential to the argument for a late first settlement. Global climate evidence and evidence based on the mismatch of even rapidly rising populations to a total defended living space for New Zealand pa of over 15 million m^2 reveal the argument for a late first settlement of New Zealand to be archaeologically and demographically flawed.

We argue that the population capacity of pa would have been at its maximum within two generations of the beginning of the Little Ice Age, when populations were still high and there were large numbers both to build and defend the largest pa. The volcanic complex of Mount Eden pictured is 0.75 km long and 196 m high at the summit. Its size and the extensive terracing to establish living areas imply a large population at the time of initial construction. Over time, with drastically falling populations, the area initially provided as living may have been underutilized by a factor of 3 to 4.

Our numerical exploration has demonstrated some of the demographic consequences of a late settlement date. But a number of questions suggest themselves, questions which we propose to answer in Chapter 15, when many lines of evidence have been brought together. If the population in the late 18th century was not a peak population, but was indeed the remnant of a far higher population that had been reached much earlier, how high was that population before it became subject to the devastating population losses of the Little Ice Age?

11.4 Environmental Evidence and First Settlement Dates

Though in the light of the arithmetic above, the suggestion of AD 1200 as a first settlement date may be absurd, from an archaeological viewpoint it is not surprising. The earliest archaeological evidence for "slash and burn" horticulture (the cutting and burning of forest to provide land for crops) comes from charcoal in lake sediments dated to around AD 1200 [15]. This evidence for the earliest horticulture in New Zealand is mistakenly taken to imply the arrival of the first migrants. While this may be a natural confusion, it flies in the face of the long history for New Zealand recorded in oral traditions. The introduction of the kumara to New Zealand can be dated to about AD 1200 from a chronology we develop from oral traditions correlated with El Niño proxy data (see Chapter 17). The dating from tradition for the medieval introduction of horticulture to New Zealand matches the evidence from lake sediments.

Evidence for slash and burn horticulture is evidence of an archaeologically visible human impact on environment. Hunter/gatherers have a far less visible presence. The supposed absence of evidence of the environmental impact of man in New Zealand till about AD 1200 reflects the change at that date to a more archaeologically visible horticultural way of life. The extinction of large fauna, for example, is linked to the slash and burn destruction of forests to create horticultural fields.

Evidence for environmental impact, for the creation of an archaeological footprint by the earliest colonists in New Zealand, has probably been destroyed. The truism that "the absence of evidence is not evidence of absence" is particularly relevant to New Zealand which, Patrick Grant [16] points out, has a long history of coastal, valley and hillside erosion. He presents detailed evidence for widespread erosion during recurrent "warm wet erosion periods" and evidence for the cumulative impact of such erosion on landscapes and recurrent impacts on biota. He argues:

> The time of first settlement may never be known. It is shrouded by the inevitable destruction of evidence. Rate of destruction varies with rainfall and landscape. The greater the rainfall, the steeper and higher the land relief, and the more susceptible to erosion the regolith and rock, the shorter will be the life expectancy of evidence for anything in the past. In valley bottoms, old alluvial surfaces have largely been eroded away or covered by later alluvium. And older hillslope soils have been eroded and replaced by younger soils on fresh surfaces. Favoured sites for building, on river banks and at estuaries, are the same now as then. These sites are very easily destroyed in an erosion period. This is the reason why sites relating to early periods of settlement are difficult to find (pp. 189–90).

Writing the above in 1994, Grant was thinking back to a possible first settlement of New Zealand in about AD 950. His argument applies still more surely to the first settlement we propose 2,000 years before that. Grant gives evidence of six major erosion periods in the last 1,600 years alone. Some of this evidence is considered in the next chapter.

11.5 The Impact of Climate on Demography

Our evidence for a Lapita-age first settlement of New Zealand is not as simple as discovering Lapita pots in the South Island (which according to tradition was settled before the North). It lies in prehistoric demography, in the calculation of population patterns from archaeological evidence, most notably from evidence implicit in the most visible archaeological evidence in New Zealand, Maori pa. Of special importance, as we show in Chapters 14 and 15, is evidence for the huge population capacity of pa and evidence from a power law approach based on pa rank size distribution curves, which allows estimates to be made for a founder population, for the total population of the North Island in 1445 and for a time depth for Maori in New Zealand stretching back nearly 3,400 years from the present to a Lapita-age first settlement of New Zealand. As we show in Chapter 14, evidence for a Lapita-age first settlement relies too on demographic evidence that can be derived from skeletal analysis. And it rests too on recognition of the powerful driving force of global climate change in shaping demographic history, not only in New Zealand and Polynesia but globally.

Before we develop the demographic arguments on which evidence for a very early first settlement of New Zealand depends, we need to digress to consider global climate change and its manifestations in New Zealand. Presenting New Zealand patterns of population growth and collapse in a global context with numerous comparable examples for the same periods from other parts of the world will enable us to demonstrate that the prehistoric demography of New Zealand both during the Medieval Climatic Optimum and in the Little Ice Age is far from idiosyncratic or unique. The context of global climate change is our focus in the next chapter.

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Chapter 12
The Context of Global Climate Change: Climate-Driven Demography

Abstract The demographic assumption of late settlement theorists is of a population rapidly increasing over 200 years from AD 1200 to AD 1400, during the warm global climate period (the Medieval Climatic Optimum) and then, in contradiction to global patterns, continuing to increase at the same rate during the Little Ice Age. A continuous population increase might be arguable if there were no evidence of food scarcity and of associated conflict over land and resources after 1400 due to the global cold conditions of the Little Ice Age. The 7,000 pa (hill-forts) built during this period and the extreme population decline rates derived from an analysis of skeletal data in Chapter 14 both contradict this assumption. The conclusion that follows is that population levels in New Zealand were high enough at the beginning of the Little Ice Age for ceilings of sustainability to be breached when adverse climatic conditions reduced the biota. Given the large landmass of New Zealand, population levels would have to have been very considerable for this to have happened. High populations by AD 1400 imply significant time depth for settlement in New Zealand, given that till AD 1200 New Zealand would have had a population growth rate consistent with a settled hunter/gatherer population, rather than one appropriate for a horticulturally based society.

Keywords Climate-driven demography · Medieval Climatic Optimum · Little Ice Age · Global climate change · Erosion · New Zealand · Population ceilings

12.1 Introduction

Considerable advances have been made in the last two decades in climate research, most notably in the understanding of ENSO (El Nino Southern Oscillation events). The severe El Niño events of 1982–1983 and 1997–1998 triggered deep general concerns about the possible consequences of global warming and brought new interest in climate history. Hoping to predict future climate patterns, researchers have turned to the past for data and for insights from past patterns of climate change. Though published in 1972, the classic book on climate history, H.H. Lamb's

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Climate, Present, Past and Future [1] is unequalled both in its comprehensive detail and scope. Lamb defines the two global climate periods of most relevance to our study. The Medieval Climatic Optimum [2], which lasted 200–300 years, brought the warmest conditions the planet had known for about 8,000 years. The timings for this period were not entirely synchronous: they varied between northern and southern hemispheres and with latitude. For example, Lamb tells us, “In the heartland of North America, as in European Russia and Greenland. . . the warmest times may be placed between about A.D. 950 and 1200. In most of Europe the warmest period seems to have been between 1150 and about 1300, though with notable warmth also in the late 900 s. In New Zealand the peak may have been as late as 1200 to 1400” [3].

The remarkable warmth of this period ended abruptly with the onset of the Little Ice Age which lasted in many places until the beginning of the 20th century, the harshness of conditions varying with time and location. This period brought with it the coldest conditions in 1,800 years. In areas with cooler climates, the favourable warm conditions of the Medieval Climatic Optimum led to extensions of horticulture, both in the varieties of crops and in the locations in which they could be grown. It led, too, to a dramatic increase in fish stocks – rich harvests on sea and land. Such bounty led to significant population increases and general prosperity. In Europe, for example, this prosperity is reflected in the undertaking of major building projects, such as the construction of cathedrals. The demographic consequences of the Little Ice Age were the opposite: widespread crop failures, the abandonment of horticultural land, migration, starvation and population collapse.

How extreme the demographic consequences were, varied in different parts of the world. The population of Britain, for example, tripled in the Medieval Climatic Optimum, then plummeted by 10% in the 1290s alone, though this was only the first decade of cold conditions that were to last for at least 400 years. Studying pa-building in New Zealand during the Little Ice Age, in this climate context, and in terms of the associated global demographic patterns for cooler climates, enables us to make sense of the extraordinary number of pa.

The demographic assumption of late settlement theorists is of a population rapidly increasing over 200 years from AD 1200 to AD 1400, during the Medieval Climatic Optimum, and then, in contradiction to global patterns, continuing to increase at the same rate during the Little Ice Age. A continuing population increase would be reasonable if New Zealand lacked the evidence, common elsewhere in the world during the Little Ice Age, of food scarcity and associated conflict over land and resources. Evidence for environmental deterioration from midden analysis and from the 7,000 pa built during this period challenge the assumption of population increase.

Evidence for severe food shortages in New Zealand during the Little Ice Age and associated conflict over land and resources supports the conclusion that population levels in New Zealand were high enough when adverse conditions affected the biota for ceilings of sustainability to be breached. Given the large landmass of New Zealand, population levels would have to have been very considerable for this to have happened. High populations by AD 1400, the beginning of the Little Ice Age, in turn imply significant time depth for settlement in New Zealand, given that till AD 1200 New Zealand would have had a population growth level consistent with a settled hunter/gatherer population, rather than with a horticulturally based society.

If there were high populations at the beginning of the Medieval Climatic Optimum, the global warm period which Patrick Grant dates to about AD 1180 in New Zealand, this can only have been the result of natural increase over a long period of time.

Robert May [4] estimates the annual average population growth rate for pre-agricultural hunter/gatherers was of the order of 0.001% per annum. For present-day New Guinea hunter/gatherers, Garry Law quotes 0.03% as a possible population growth rate [5]. These figures, of course, presuppose a long time scale with balance achieved between population and available resources so that close to a nil growth rate is being maintained. In New Zealand initial growth rates, even given a settled hunter/gatherer existence, would have been higher than this. But neither the fast initial growth rates possible in tropical Polynesian islands with horticulture nor the rates possible for an agricultural society such as that of medieval England could be sustained long term in New Zealand. We considered a high initial growth rate of 0.5% per annum in the last chapter in order to demonstrate its inadequacy for generating a sizeable population by the time of Cook. A growth rate of this level is 17 times Law's estimate for New Guinea.

A rate of increase that could enable British populations during the Medieval Climatic Optimum to triple in 200 years (0.55% per annum) could not be sustained for long in prehistoric New Zealand and certainly not during the extreme conditions of the Little Ice Age. Sutton's study of nutrition, as we have seen, makes it clear that Maori would always have relied primarily on hunting and fishing and that this would have continued even after the introduction of the Polynesian cultivars and the beginning of organized horticulture in New Zealand after about AD 1200. The extreme cold of the Little Ice Age would have impacted on the biota at every level in every part of the country: fish, shellfish, birds, seals, forest foods, kumara and other crops would all have been reduced. If population levels in New Zealand were high in AD 1400, there would be population decline, probably long and sustained in New Zealand, rather than short and sudden and tied to specific crop failures in particular years, as in England and northern Europe. After AD 1400 it would probably have extended to the best lands as well as to the marginal, and there is little doubt that, as elsewhere in the world in the Little Ice Age, high populations and sudden reductions in food would have triggered starvation and conflict over land and resources. Fear of attack and concern with tribal survival are implicit in the extraordinary level of pa-building in New Zealand. The limited numbers of radiocarbon dates for pa that have so far been obtained place them centrally in the Little Ice Age. The obvious implication is that populations were high enough for ceilings of sustainability to have been breached in Little Ice Age New Zealand and so for starvation and significant population losses to have occurred in New Zealand as in Europe.

12.2 Climate-Driven Demography

Studying the two juxtaposed periods of extreme warmth and extreme cold in Europe, the Medieval Climatic Optimum and the Little Ice Age, makes particularly obvious a context in which climate drives demography.

The prime requirement is a population nearing the limit of its resources, of its ceiling of sustainability. To this add extreme, adverse, climatic conditions which reduce the biota and/or destroy vital food resources and thus independently and additionally lower the ceiling of sustainability. The inevitable result is starvation, population collapse and, potentially, extinction.

In northern Europe thriving agriculture, prosperity and a dramatic population increase during the Medieval Climatic Optimum were followed by crop losses, widespread starvation and population decline caused by the climate extremes of the Little Ice Age impacting on high populations. In New Zealand and in tropical Polynesia, as we shall explain shortly, the picture is more complex. But to offer first a simple, unambiguous example of climate-driven demography, we turn to Iceland.

Lamb provides figures from Iceland, based on demographic data obtained from tax records. Drawing on the work of Thorarinsson, Lamb provides a table giving Icelandic population levels from AD 1095 to AD 1960 [6]. We present these in Table 12.1. We have added percentages for population growth, implicit in the

Table 12.1 Population growth and decline in Iceland AD 1095–1960

Population Growth/Decline	Date AD	Population
	[after 860]	[3,000]
[1.39]		
	1095	c. 77,520 (from tax records)
–0.032		
	1311	c. 72,420 (from tax records)
–0.092		
	1703	50,358
–0.35		
	1784	c. 38,000
0.045		
	1801	47,240
0.51		
	1901	78,470
1.39		
	1960	177,292

figures, in a column on the left. We have also added an estimated founder population of 3,000 and an initial growth rate of 1.39% p.a. This growth rate matches the highest such figure in the table (1.39% for the period 1901–1960). This period is undoubtedly closer in temperature than any other in the table to the warmth of the Medieval Climatic Optimum, when demonstrably after 235 years of warm conditions, the population had reached 77,520 [7]. The high initial growth rate for Iceland is consistent with its being an agricultural society with sheep and cattle and pigs, initially able to maintain contact with its homeland, able to grow several cereal crops and possessing an enslaved labour force (possibly not represented in Thorarinsson's data).

Table 12.1 shows the peaking of population following the favourable conditions of the Medieval Climatic Optimum, then a long, slow, continuous fall in population with the advent of the Little Ice Age. There is, indeed, a 689-year period of continuous population decline in Iceland from AD 1095 to AD 1784. In Greenland the same pattern of population peaking in the Medieval Climatic Optimum and falling drastically in the Little Ice Age occurs, but the outcome for the population of this Norse settlement was extinction. The Icelandic population survived, but it took 800 years for Iceland's population at AD 1095 to be reached again.

The demographic pattern we see in Iceland in this very clear example, with demographically unimpeachable data, is found throughout northern Europe, though often there famine is tied to harvest failures in specific years or decades during the Little Ice Age. Lamb, comparing Iceland and Scotland, for example, notes that "in the upland parishes in Scotland, in the successive harvest failures in the 1690's, it has been estimated that about one third of the population died". It was this catastrophe that forced Scotland into union with England [8] and prompted the Scottish colonization of Ulster. Aimed at reducing the population burden in Scotland, this migration led to the sectarian conflict in Ireland that has lasted down to the 21st century.

These examples from Iceland, Greenland and Scotland all show the demographic consequences of extreme climate change for populations which have reached their ceilings of sustainability. If extreme climatic conditions reduce food resources in these circumstances, survival ceilings are independently lowered. Starvation follows and, as we see from the Norse colony in Greenland, this can lead to population extinction.

Though all three European examples record the effects of global climate change on demography, it is clear from Lamb's wide-ranging study that the expressions and consequences of global climate change in different parts of the world, even though driven by the same global climate extremes, may not be synchronous or comparable. In different parts of the world, the extremes both in good and adverse conditions and in population increase and decline, driven by differing expressions of the same global climate patterns, can vary markedly. There can be considerable variation both within and between hemispheres and between latitudes, with local, regional and global conditions in concert affecting outcomes for different areas.

12.3 The Medieval Climatic Optimum in Tropical Polynesia

How relevant the climate-driven demographic patterns of Europe during the Medieval Climatic Optimum and Little Ice Age are to New Zealand, we shall discuss shortly. First, it is useful to consider their relevance to tropical Polynesia. It was not so much during the Little Ice Age that the tropical Polynesian islands suffered but during the preceding warm period. During this period El Niño-driven drought and famine triggered warfare over land and resources within islands and archipelagoes. Drought and famine prompted migrations and also effectively led to invasions, as seen, for example, in the southern incursions into Hawaii in about AD 1100 from Samoa, Tahiti and the Marquesas. Southerners effectively took control of the Hawaiian Islands, replacing indigenous chiefs and priests with their own. These southern incursions had a lasting cultural impact even after Hawaii's isolation was restored when voyaging conditions deteriorated at the end of the Medieval Climatic Optimum (in Hawaii, following northern hemisphere patterns, in AD 1250–1300).

The pattern of warfare, invasions and enforced migrations that we see operating in tropical Polynesia in the Medieval Climatic Optimum occurred 300 years earlier than in New Zealand. In tropical Polynesia recurrent El Niño-driven drought, not cold, was the climatic factor that impacted on populations which had reached their ceilings of sustainability probably by about AD 900 (see Chapter 19).

The increasing numbers of migration canoes reaching New Zealand during the Medieval Climatic Optimum, probably carrying the starving and the defeated in effectively enforced migrations, bear witness to the worsening of conditions in tropical Polynesia, as well as to optimal voyaging conditions to New Zealand. Perhaps at no time since the period before 1000 BC that saw the Lapita migrations into the Pacific were voyaging conditions to New Zealand better than during the Medieval Climatic Optimum. Safer migration to New Zealand, combined with overpopulation, starvation and defeat in warfare in the tropics, would have provided greater incentives for migrating to a distant New Zealand than for migration within Eastern Polynesia, much of which may have been severely drought-affected. Very considerable population losses in tropical Polynesia in this period seem likely and may have continued into the Little Ice Age if populations still outstripped resources. The response of the Hawaiians to the arrival of Captain Cook's ships, recorded in the diary of the second-in-command, James King, suggests that this could have been so [9]. King writes that the Hawaiians

> imagined we came from some country where provisions had failed; and that our visit to them was merely for the purpose of filling our bellies. Indeed, the meagre appearance of some of our crew, the hearty appetites with which we sat down to their fresh provisions, and our great anxiety to purchase, and carry off, as much as we were able, led them, naturally enough, to such a conclusion.

Ross Couper-Johnston [10] quotes an even stronger record of starvation in the story of the last king of Niue:

> The body of the last recorded Patuiki or king of Niue, a French Polynesian island with no natural supply of surface water, was discovered in the forest during a great famine. His death, which probably dates to the exceptionally strong 1790–93 El Niño, is still

remembered and he is known today as Ike ne kai he kuma he mate pipili, or 'The king that was food for the rats when he was starving'.

In isolated islands, such as those of tropical Polynesia, food resources are constrained by land area and by the limits of horticultural technology. When highly populated, such islands are particularly vulnerable to climate extremes. Their boom/bust demographic patterns have been commented on by demographers. Alexandra Brewis and John Allen, for example, comment: "One characteristic of Pacific populations which may set them apart from other populations is a long-term tendency towards growth, coupled with habitual periodic population collapses, most particularly under atolline conditions" [11]. The extinction of species at each crisis point through over-hunting and over-fishing renders an island permanently poorer, less able to support high populations. The terrible example of the devastation of the ecology of Easter Island shows the process close to end-point.

12.4 A North American Analogue

We can set the resource crisis faced by tropical Polynesia in the Medieval Climatic Optimum in a wider context by considering a paper published by Terry Jones and 15 other authors in 1999 [12]. This paper provides a detailed North American analogue for the drought-driven demographic crisis that faced Eastern Polynesia during the Medieval Climatic Optimum. The beginning of their abstract provides a quick summary of their thesis:

> Review of late Holocene paleoenvironmental and cultural sequences from four regions of western North America shows striking correlations between drought and changes in subsistence, population, exchange, health, and interpersonal violence during the Medieval Climatic Anomaly (A.D. 800–1350). While ultimate causality is difficult to identify in the archaeological record, synchrony of the environmental and cultural changes and the negative character of many human responses—increased interpersonal violence, deterioration of long-distance exchange relationships, and regional abandonments—suggest widespread demographic crises caused by decreased environmental productivity. The medieval droughts occurred at a unique juncture in the demographic history of western North America when unusually large populations of both hunter-gatherers and agriculturalists had evolved highly intensified economies that put them in unprecedented ecological jeopardy (p. 137).

The authors comment that the Medieval Climatic Anomaly

> was a time of increased aridity that coincided with a unique pattern of demographic stress and frequent economic crises across much of western North America. Large populations of agriculturalists and hunter-gatherers were confronted with serious and abrupt declines in productivity caused by repeated and prolonged droughts. . .We believe that the plethora of cultural changes and the negative character of many of them reflect widespread crises related to population/resource imbalances, drought-related environmental deterioration, and shortages of food and water (p. 138).

They argue that the period between AD 800 and AD 1350 was punctuated by "epic droughts" and that these droughts "and the more broadly timed episodes of increased temperatures attendant upon the Medieval Climatic Anomaly had direct effects on terrestrial ecosystems by impacting water sources and reducing primary production and therefore harvestable biomass" (p. 138).

To establish their claims the authors focus on the effects of these droughts in the Great Basin and Sierra Nevada, the southern Californian coast, the Mojave Desert and the Colorado Plateau (p. 142), providing detailed discussion of the cultural and demographic consequences of "epic droughts" in all four regions. They argue that archaeological sequences from the four regions show

> striking correlations between changes in subsistence, interregional exchange, frequency of warfare and interpersonal violence, regional abandonments, and major population movements, on the one hand, and events in the paleoenvironmental record, on the other. Specific cultural responses vary between regions, but each shows diachronic changes that are difficult to attribute to simple adaptive adjustments or economic intensification. Rather, events in each of these regions are best explained as responses to environmental deterioration and demographic stress (p. 145).

The authors show the same patterns affecting agricultural and hunter-gatherer regions and document responses to demographic stress in both in some detail. In northern Colorado, for example, they note

> Agricultural settlements across much of the northern Colorado Plateau were abandoned during a subsequent epic drought between 1130 and 1150, while populations aggregated to the south and east. Nucleation was ultimately curtailed during the Great Drought with the final collapse of settlements across most of the central Colorado Plateau. Centuries of population growth limited the subsistence options that were formerly available to dispersed farming groups, and during the later droughts many Pueblan populations were beyond a carrying capacity that had declined as a result of extended drought. Throughout the late medieval period there is mounting evidence for intergroup warfare and interpersonal violence in this context of food stress (p. 155).

For both agriculturalists and hunter/gatherers they conclude that "Situations in the case studies considered here are best explained in terms of a convergence of rapidly growing human populations and precipitous declines in environmental productivity" (p. 156).

The examples we have quoted from Europe, tropical Polynesia and North America of global climate extremes impacting in different ways and in different eras on populations which had reached or breached their levels of sustainability provide a context in which we can now examine the climate-driven palaeodemography of New Zealand . These examples illustrate the fact that whether it is drought or cold that impacts on a biosystem and drastically reduces food availability, demographic consequences will vary according to the margins for sustainability to be found among affected populations. These margins will vary not only from country to country but from region to region within a country. In the same period of resource depletion, people in the poorer Scottish highlands will suffer more rapidly and extremely than those living in the more fertile areas of Surrey. All faced with climate-driven famine will be forced to seek adaptive means for improving their chances of survival. Some hunter/gatherers may adopt horticulture at least temporarily; others may raid horticulturalists' harvests. Where opportunities for migration are limited, conflict over land and resources is inevitable: for each tribe or group success in seizing or maintaining control of land and resources will ultimately determine demographic outcomes. Thus the sudden proliferation in pa-building in New

Zealand in the Little Ice Age in a time of extreme resource depletion might be seen as an extreme example of adaptive response, reflecting initial high populations and extreme demographic stress.

12.5 Climate-Driven Demography in New Zealand

New Zealand has a larger land area than all the other Pacific islands together. A far longer time depth is needed in New Zealand than in tropical Polynesia for a population to outgrow resources and so for the conditions for a climate-driven demographic catastrophe to be met. As our argument against a late first settlement implies, with a population growth rate appropriate to New Zealand's settled hunter/gatherer mode, a very long time would have been needed for populations to have reached levels high enough for them to reach or breach ceilings of sustainability and so become vulnerable to adverse climatic conditions.

The first occasion in which this could have happened was probably during the 50-year-long warm wet erosion period from AD 950 to AD 1000, by our estimate, about 2,400 years after a first settlement which we date in Chapter 20 to about 1400 BC, a date supported by demographic analysis in Chapter 15. We shall present evidence in the next chapters to establish that, in some areas by the beginning of the Medieval Climatic Optimum, and in all areas throughout the Little Ice Age, the vulnerability of populations in New Zealand to adverse climatic conditions resulted in severe and in some areas continuous population decline. We argue that the conditions leading to this population decline explain the extraordinary proliferation of Maori pa during the Little Ice Age. For there is implicit evidence in the 7,000 pa built then of the starvation and ensuing conflict over land and resources that followed the loss of biota during intense cold periods in the Little Ice Age.

In New Zealand the pattern of climate-driven demography appears to be more complex than in Europe and to find a more extreme and longer-lasting expression. Both in the Medieval Climatic Optimum and in the Little Ice Age two kinds of contrary adverse climatic factors were operating in New Zealand. Warmth, normally favourable to the growth of fish stocks, forest foods and horticultural crops – as was the case in northern Europe in the Medieval Climatic Optimum – can be accompanied in New Zealand by heavy rainfall leading to floods and erosion and by gales destroying forests with loss of forest biota.

12.6 Warm Wet Periods and the Destruction of Archaeological Evidence

Patrick Grant [13] defines eight "warm wet erosion periods" for New Zealand in the last 1,600 years and claims that all led to major disturbances of the landscape and destruction of biota. With permission, we have reproduced Grant's diagram (Fig. 12.1) showing both warm erosion periods and cold periods.

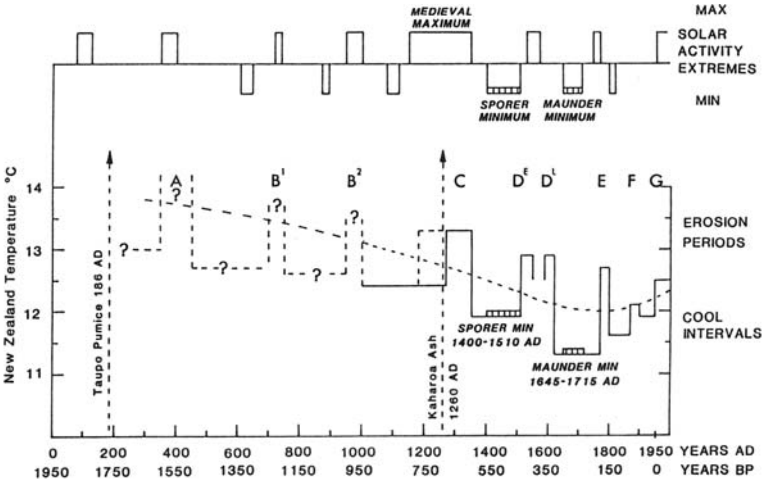

Fig. 12.1 Global climate change in New Zealand AD 200–1950. Reproduced with permission from Auckland University Press

Grant's discussion of his diagram is pertinent:

> The climate model is derived by combining the erosion period chronology with the New Zealand palaeotemperatures from speleothems and tree cellulose, for the last 1000 years. Erosion periods are: Post-Taupo (A), Pre-Kaharoa 1 (B1), Pre-kaharoa 2 (B2), Waihirere (C), Early Matawhero (DE), Late Matawhero (Dl), Wakarara (E). Tamaki (F), and Waipawa (G). Cool intervals include the one preceding the Waihirere period, and the intervals containing the Sporer Minimum (1400–1510 AD) and the Maunder Minimum (1645–1715 AD). The long-term mean temperature curve is more doubtful before 1000 AD, but after that it shows a progressive decrease in temperature until 1715 AD, since when it has risen. Solar activity extremes are for limited spans of time, but extreme maxima coincide closely with the erosion periods, and extreme minima with the cool intervals (p. 169).

One of the warm, wet erosion periods, the Warm Waihirere Period (AD 1180/1270–1350) occurred during the Medieval Climatic Optimum. (Grant proposes AD 1180 as the beginning of the Medieval Climatic Optimum in New Zealand.) Two other short warm erosion periods, the Early Matawhero Period (AD 1510–1550) and the Late Matawhero Period (1590–1620), remarkably, occurred during the Little Ice Age (p. 171).

Grant offers a powerful description of the scale of erosion and its effects on landscape and biota in the last 1,600 years:

> Study of the patterns of sedimentation and alluviation in river systems representing the results of the erosion of New Zealand mountains over the last 1600 years has revealed eight distinct periods of greatly increased erosion of mountain and hill slopes and of stream and river banks. Large quantities of sediment were supplied to, and transported through, drainage systems. Channels aggraded, widened, straightened and steepened; and erosion of riparian land also increased. Sediments accumulated in valley bottoms and on flood plains. Outwash sediment fans formed widely, and up-slope materials accumulated as colluvium on lower slopes and their toes. New lakes resulted from valley blockage by alluvial sediments. Existing lakes and coastal estuaries became shallower due to rapid sedimentation. Between

> the erosion periods there were longer tranquil intervals when erosion and sediment transport declined, the fresh surfaces were revegetated, and soils formed.
>
> The examples which follow give some idea of the magnitude of the geomorphological changes brought about by the erosion periods of the last 1600 years. In the valley of the Wairoa River, northern Hawke's Bay, there was alluvial infilling of 18m; in the middle reaches of the Whangaehu valley, in the central North Island, it was 13 m. On the Canterbury Plain around Christchurch, alluvial accumulation was at least 6 m; on the Wairau Plain near Blenheim, it was at least 10.5 m; and on Heretaunga Plain, near Hastings, it was locally as much as 14 m. (pp. 164–165).

An archaeologist would have to dig deep to find evidence only 1,600 years old. To dig deep enough to find direct archaeological evidence for a first settlement 3,000 years ago may be well nigh impossible. Indeed, Herries Beattie [14] quotes several examples of archaeological evidence found at considerable depths, although all are far closer to the surface than the base of the alluvial deposits listed by Grant above:

> In 1924 Captain J. Bollons, master of the S.S. Tutanekai, wrote as follows: 'There is evidence that natives have been in New Zealand for a much longer period (than 800 years). . .To give one instance of the remoteness of time when people were residing on Rakiura, or Stewart Island. Some 20 years ago natives were digging a trench round their whare on the small titi island, Horomamae, situated off the south-east coast of Rakiura. Having cut down to a depth of six feet through purely vegetable deposit, they came to a layer of shell and charcoal, one foot in thickness. Amongst this, hangi or food debris was found, four stone tools of adze or chisel shape, one being of greenstone, all of similar construction and showing the same method of cutting as tools found on the present-day surface at other places. The plant covering of this islet is principally that shrub with thick leathery leaves known as pukeretaiko, or muttonwood of the settler (senecio rounitolina), which sheds its leaves but slowly. An idea of the length of time it would take to form six feet of deposit can be imagined.'
>
> The New Zealand Mines Record, August 1897, says at Bald Hill Flat , near the foot of the Old Man Range, Maori chisels, wooden bowls and earth ovens were found in the sandstone clay at a depth of 16 feet, the bowls being very little decomposed.
>
> The Maoris told me that when the navvies were digging the railway cutting at Puketeraki they found a shell midden some 16 feet under the surface.
>
> Macmillan Brown wrote: 'That the pre-Polynesians in New Zealand had used steam-ovens is evident by their having been found as much as 14 feet below the surface of the soil, as, for example, on the Manuherikia Plains in Central Otago. . .The slow accumulation of alluvium, wind-blown soil and humus on such high plateaus forces us to place the age of this back into the thousands of years. . .The most careful and scientific description of the find of a stone implement in the soil is that given by Sir Julius von Haast of a partially finished chert adze and its sandstone sharpener, found by a party of gold-miners in Bruce Bay, Westland, in 1868. They were lying on a floor of pebble-studded clay, and more than 14 feet of strata of humus, sand and shingle had to be cut through before this was reached. Totara trees, four feet in diameter, had to be felled before the surface could be broken. . .the place was 500 feet above highwater mark. . .take us back undoubtedly several thousand years, and even then we have a neolithic race that polished its weapons and had spread so far west and south towards the long uninhabited sounds'.

As we shall suggest in Chapter 16, there is a possibility that Mahitahi (Bruce Bay) may have been the place where the first New Zealand settlers landed. That artefacts were found there deep below the surface may not be anomalous. For tradition suggests that, rather than being "long uninhabited", Bruce Bay may have been amongst the earliest inhabited sites in New Zealand, so that the finding of tools there 14 ft below the surface is not surprising.

12.7 The Medieval Climatic Optimum in New Zealand

Grant's description makes clear the risk of starvation to Maori populations dependent on forest, marine and estuarine resources, once population levels were high and resources, scarcely adequate, were suddenly reduced by floods and forest destruction. Given our premise of a very early first settlement, it is likely that populations were high enough by AD 1180, the beginning of the Warm Waihirere Period, and similarly by AD 1510, the beginning of the Early Matawhero Period, for there to be some population decline in both these adverse climate periods. It seems likely that in the less well-resourced areas populations would be especially vulnerable and that to some extent at least this vulnerability must have affected all areas.

We can, however, expect a significant difference after about AD 1200, when the kumara, taro, yam and gourd were introduced to some areas of New Zealand, areas some of which were later to become major pa areas. The large-scale establishment of horticulture can probably be attributed to the favourable warmth of the Medieval Climatic Optimum. Good harvests could be expected then and would have been a buffer against starvation. We think it likely that populations in horticultural areas, which in the warmer Medieval Climatic Optimum may have included areas in the south of the North Island, were largely protected from the population decline suffered in the non-horticultural areas during the Warm Waihirere Period. The major horticultural areas included Taranaki, the Bay of Plenty, the Bay of Islands, the Auckland Isthmus and the northwest coast of the North Island, which were able to exploit rich alluvial and volcanic soils to grow the newly introduced tropical cultivars and especially kumara. Rich not only in good soils but in marine and estuarine resources, these areas in some cases had added resources from lakes and rivers and good harbours giving access to offshore fishing. Indeed, these optimal areas may always have supported the largest populations in New Zealand. Probably many of the earliest settlements in the North Island were located in these resource-rich areas. The alluvial soils that allowed a thriving horticulture to be established in these areas in the Medieval Climatic Optimum, however, are evidence of the vulnerability of these areas to erosion. They offer testimony to the likely deep burial of evidence for earlier settlements in these choice locations.

12.8 The Little Ice Age in New Zealand

Assuming an early first settlement and significant populations by the beginning of the Little Ice Age, conditions would probably have deteriorated in the Little Ice Age even in the favoured areas. For cold would have reduced kumara harvests drastically. Though adapting the kumara, which was a perennial in tropical Polynesia, through skilful horticultural practice, to function as an annual in New Zealand, would have given the plant some protection against the cold, the ancient varieties were probably both lower-yielding and less cold-resistant than the modern varieties now grown in New Zealand.

A simultaneous reduction in horticultural harvests and in forest biota, shellfish and fish stocks in the Little Ice Age, following on the heels of earlier reductions of biota during the Warm Waihirere erosion period, may have brought starvation to these richer areas for the first time. The global context suggests that it is unlikely, given the severe cold of the Little Ice Age, that even these favoured areas would have escaped exposure to starvation.

The scale of pa-building implies extreme conflict over land and resources triggered by the climate-driven destruction of biota. It is no coincidence that in New Zealand over 98% of pa were built in horticultural areas during the Little Ice Age to defend cultivable land and stored harvests. Both horticultural land and stored harvests were clearly seen by the tribes in the pa areas as crucial to their survival in a time of depleted natural food resources. How severely starvation was felt in the richer areas is the subject of discussion in the next chapters where we show that the extent of its impact can be estimated in some degree from demographic evidence implicit in available data for the Maori pa and from comparison with demographic patterns in the poorer areas of New Zealand for which we have some explicit evidence from skeletal analysis.

We need to stress that in poorer areas in New Zealand high populations at the beginning of the Medieval Climatic Optimum are a necessary condition for significant population decline during this period. Small populations would have been affected minimally by adverse climate for, with little competition for resources, loss of biota would not lead to starvation.

Extreme climatic conditions and significant population decline from starvation are both needed to establish that a context of global climate-driven demography is relevant to New Zealand – in poorer areas during the Medieval Climatic Optimum and in all areas during the Little Ice Age.

At the simplest level, climate researchers in New Zealand have found proxy evidence from dendrochronology (analysis of tree rings) and speleothems (stalactites and stalagmites) for the impact of these two global periods on temperatures in New Zealand [15]. Grant, as we have seen, supplies evidence for the reshaping of landscape through erosion in these periods and claims widespread damage to forests, coastlines and estuaries and their biota through warm wet erosion periods. His evidence strongly supports the first condition to be met: that of climate extremes damaging food resources. Comparison with the failure of crops in northern Europe in the Little Ice Age and the loss of fish stocks and especially cod in the North Atlantic provides a context in which to envisage conditions in New Zealand in the Little Ice Age. The extinction of the moa and the reduction of seal populations in this period and evidence from middens of the reduction of fish and bird species provide evidence of loss of biota paralleling that experienced in northern Europe. Awareness of the global context provides support for our interpretation of what, at first glance, seems to be local evidence. This is the case, for example, for evidence of starvation in New Zealand.

12.9 Cannibalism in New Zealand

That starvation caused significant population decline in New Zealand during the Little Ice Age is supported by the appearance there of cannibalism – for the first time, it is claimed, in the traditions of the *tangata whenua* (the indigenous peoples: literally people of the land). In the Little Ice Age, starvation in the Norse colonies of Iceland and Greenland brought extinction for the population of Greenland and nearly 500 years of population decline for the Icelanders. Such starvation, as we have demonstrated, was common to much of northern Europe at the time. In a global context, the appearance of cannibalism in New Zealand in the Little Ice Age can be seen to echo evidence of starvation akin to that in the most severely affected countries in northern Europe and even suggests that the degree of starvation in New Zealand may have been comparable to that of Russia. Lamb [16] sees cannibalism in Europe as a measure of the desperation of the starving:

> And in one, two or three years between 1314 and 1319 almost every country in Europe lost almost the whole harvest: the poor were reduced to eating dogs, cats, and even children. . .It is from eastern Europe, however, that. . .we have the harshest climatic disasters in the late Middle Ages reported: winters of such unaccustomed severity and depth of snow that many people died and a few winters so mild that people were puzzled and anxious about seed time and harvest.
>
> There were summers with continual rains and others with such prolonged heat and drought that, in either case, the crops failed. In the ensuing famines people took in desperation to cannibalism or emigrated to the west. The accounts of those seasons in the chronicles of the monasteries in the areas that are now Poland and on the plains of Russia. . .make terrible reading. The earliest serious case seems to have been in AD 1215, when early frosts destroyed the harvest throughout the district about Novgorod, people ate pine bark and sold their children into slavery for bread, 'many common graves were filled with corpses, but they could not bury them all. . .those who remained alive hastened to the sea.' Other bad years came in 1229 and 1230, and in the latter there were many incidents of cannibalism 'over the whole district of Russia with the sole exception of Kiev.' (Reports of a few such incidents in the Middle Ages in western Europe, including the British Isles, also occur, though much more rarely.). . .From 1421 to 1423 there was a famine for 3 years in Russia, again leading to cannibalism and an exodus to the west. In 1436 similar events occurred about Smolensk, and it was reported that 'the wild animals ate people and people ate people and small children'.

Cannibalism is seen by most westerners as savagery associated with primitive peoples in past times, rather than as a universal response to starvation (although perhaps cannibalism has not been adopted at any time by a large proportion of a starving population). Ross Couper-Johnston [17] describes the more recent El Niño famine of 1877–1878 in which in China between 9 and 13 million people died and another 70 million were severely affected:

> In some counties of the north-east, up to 90 per cent of the population disappeared. . .In December 1877. . .it had become the norm for people to pull down their houses [to eat the sorghum stalks from which they were made], sell their wives and daughters, eat roots and carrion, clay and refuse. . .By the autumn of 1877, the numbers of dying became so overwhelming that corpses were buried in 'ten thousand man-holes'. . .By 1878. . .human flesh appeared on sale in the markets. However, the supply of corpses failed to keep pace

> with the desperate demand – even the living were butchered. In the words of one Catholic priest, there were no limits, 'Fathers eat sons and daughters, husbands eat wives and children eat their parents'.

In this global context, the appearance of cannibalism in New Zealand in the Little Ice Age can be read as evidence of extreme and probably widespread starvation and high population loss.

In the coldest phases of the Little Ice Age in New Zealand when starvation and related conflict over land and resources were driving forces and the declining population still exceeded resources, it is indeed likely that cannibalism appeared as a response to starvation, though, as tradition claims, it was probably restricted even then to eating only enemies killed in battle. As populations fell and subsistence levels improved, it seems possible, however, that there could have been a transition from cannibalism in response to starvation ("subsistence" cannibalism Barber calls it) [18] to cannibalism driven by need for revenge against those who continually threatened tribal security and also, of course, driven by the anger and fear that fuelled that revenge. Barber argues that cannibalism in New Zealand was a ritual expression of revenge rather than evidence of a desperate need for protein and that because of this probably little human flesh was consumed. Certainly revenge as a motivation is psychologically likely. Warfare seems to have become endemic and fear of attack constant. Even Cook, as late as 1777, believed that the Maori lived in "perpetual apprehinsions" [sic] of attack and that cannibalism was to be understood in the context of revenge [19].

Fear for the survival of the tribe, whether because of starvation or attack, was almost certainly a driving force behind pa-building, warfare and associated cannibalism. Barber notes Anne Salmond's claim that "after about A.D.1500 in the context of population pressure and resource competition (following significant bird extinctions and the decline of seal populations), warfare apparently intensified and evidence of cannibalism began to appear". The bird extinctions and decline of seal populations are evidence not only of the impact of the Little Ice Age on ecosystems but probably also of the abandonment of traditional protocols for limiting the hunting of various species to prescribed periods. Indigenous tribes, for example, had imposed protocols on the hunting of moa and other birds, such as the *potakitaki*(paradise duck), *parera* (grey duck), *weka* (woodhen), *pukaki*(swamp turkey), *keruru* (pigeon), *kaka* (brown parrot) and *koko* (parson bird), and probably maintained them for centuries [20]. Eastern Polynesian migrants and their descendants, and possibly even the tangata whenua themselves, may have chosen to ignore these protocols in the face of starvation. Certainly there is clear evidence of increasing scarcity and extinctions in some species which had been an important part of the Maori diet. Anne Salmond [21] tells us:

> By the fourteenth century the larger species of moa and elephant and leopard seals were scarce in the South Island and almost non-existent in the North. The native swan, the flightless goose, Finsch's duck, the New Zealand eagle and the native species of goshawk, coot and crow had all become extinct. By the fifteenth century fewer birds of fewer species were being caught in most North Island communities, while all species of moa were virtually extinct in the North Island and had become rare in the South.

Barber refers to the “resource crisis” which “appears to characterize the general New Zealand sequence from about the fifteenth century A.D.”, but argues that “the possibility must be considered that cultural precedents for later patterns of conflict and ritual violence were introduced by the earliest Polynesian settlers” and suggests that “a critical consideration of the evidence for cannibalism in other Pacific sequences, such as Fiji, the Marquesas, and Easter Island may also be fruitful” (p. 283). In this context he quotes Kirch’s remark that “the institutionalization of cannibalism in late prehistoric Marquesan society must be taken as a symptom of tensions which had developed between social groups, exacerbated by dense populations and recurrent famine” [22] and refers to Kirch’s comment on the development of cannibalism in the later, high-population, “Decadent Phase” of the Easter Island sequence.

The Marquesas and Easter Island offer two examples that, it seems, may parallel the demographic pattern we see in New Zealand in the Little Ice Age though, given their smaller land areas and associated limitations on population sustainability, the pattern probably took effect earlier there. We see the same vulnerability of high populations to climate-driven resource shortages and famine, the same intense conflict over land and resources, the appearance of cannibalism and population collapse.

Barber agues that in New Zealand, from an absence of archaeological evidence, “an argument for widespread or subsistence cannibalism cannot be sustained” (p. 280) and he points to “Houghton’s general observation, offered from a position of many years analysis of pre-European Maori skeletal remains from sites throughout New Zealand” and Houghton’s conclusion that “There is no evidence to suggest that large tribal battles caused much injury (or even occurred) or that cannibalism was common” [23].

We would suggest that the extraordinary labour that produced the 7,000 pa currently registered on the national site record file suggests an atmosphere of conflict. Though Best mentions pa that were never taken, there are examples in his *The Pa Maori* of some that were. For example he mentions the case of a “weak” pa defended by only 100 warriors which was attacked by 1,600, who killed 67 men and enslaved 180 of the 200 women and children [24]. A population large enough to outstrip resources in a country as large as New Zealand a few hundred years after a first settlement in AD 1200 is demographically inconceivable. It is still more improbable with the first settlement date of AD 1280 suggested in a recent paper [25]. The sheer size of the 36 volcanic cone pa on the Auckland Isthmus alone contradicts such a possibility. For example, the complex and extensive site of One Tree Hill shown in Fig. 12.2, which was defended by formidable earthworks, covers an area of 17.2 ha.

Extensive pa-building and rebuilding with the inclusion of additional defensive means, and above all the sustained occupation of pa in New Zealand during the Little Ice Age rather than their occasional use as refuges as elsewhere in the Pacific, suggests rather that the “perpetual apprehinsions” of attack Cook ascribed to the Maori more accurately represents the level of conflict and fear for tribal survival in the Little Ice Age. It is possible that the existence of so many pa and the sheer difficulty of taking the substantial ones may have proved a deterrent and so limited fighting. It is also possible that by the time of European contact, when as we shall

Fig. 12.2 The volcanic cone pa of One Tree Hill on the Auckland Isthmus. Reproduced with permission from Alexander Turnbull Library, Wellington

argue Maori populations were only a fraction of what they had been at the beginning of the Little Ice Age, cannibalism in New Zealand may have become a limited act of ritual revenge as Barber argues. But in the most extreme conditions in the Little Ice Age when populations were high and starvation threatened survival, cannibalism, limited to eating enemies killed in warfare, was probably a survival strategy.

It is interesting to note that Maori, unlike starving Europeans in the Little Ice Age and starving Chinese in the late 19th century, did not eat their own children. There appears to have been a reluctance to accept cannibalism in prehistoric New Zealand and in parts of Polynesia that can be seen not just in limiting cannibalism to enemies killed in battle but in their traditional account of the introduction of cannibalism to tropical Polynesia. The traditional story of Kai-tangata (a name which means cannibal) and his demoness wife, who introduced cannibalism for the first time, mentions a great famine at the time of the birth of their son, Hema. In Chapter 19, through the use of a Hawaiian solar eclipse, dating for a severe El Niño-induced drought and famine, and dating from analysis of two Hawaiian genealogies, we are able to establish an exact date for Hema's birth at AD 903. This means that the link between starvation and cannibalism is recognized in tradition relating to events as early as AD 903 and suggests that extreme climate conditions drove demography in tropical Polynesia by this date at least. The story shows a general rejection of cannibalism: despite his name, Kai-tangata rejects the eating of human flesh, which his pregnant demoness wife craves. This rejection of cannibalism is, however, combined with an implicit recognition that starvation and cannibalism occur together. A general reluctance, or suggestion of guilt, emerges both in this story and perhaps in New Zealand in the Little Ice Age in the claim that cannibalism had appeared there for the first time. Maori insisted that it was not indigenous but had been brought there by the medieval migrants from Eastern Polynesia (for whom, as the traditional story of Kai-tangata suggests, El Niño-driven famine was by then a recurrent experience).

In this chapter we have created a global context in which the building of Maori pa and the appearance of cannibalism in New Zealand can be viewed not as surprising local phenomena but as responses to global climate extremes. Both can be viewed as evidence not only of a marked intensification of conflict over land and resources in New Zealand during the Little Ice Age but also of the starvation provoking that conflict. Such evidence and the recognition of climate-driven demography are a vital background to our demographic argument for a very early first settlement. For, as we have argued, populations in New Zealand high enough by the beginning of the Little Ice Age to be exposed to widespread starvation following the loss of biota imply a very considerable time depth in New Zealand for indigenous populations. Population growth before AD 1200 with a settled hunter/gatherer society was inherently limited so that the establishment of high populations by the beginning of the Little Ice Age is evidence for a long demographic history for Maori in New Zealand.

12.10 Erosion Triggered by Earthquake and Tsunami: Added Destruction of Archaeological Evidence

The erosion history of New Zealand, we have argued following Grant, is climate-driven, linked to recurrent warm wet erosion periods. Recent geological and geomorphological evidence, however, has focussed on another major cause of erosion in New Zealand linked not to wet erosion periods, which reflect global climate patterns, but caused by local tectonic activity. Because New Zealand sits astride the boundary or interface between two major tectonic plates, the Australian and the Pacific, the country is tectonically active. Numerous fault lines and a history of earthquake clusters and tsunamis reflect this activity. As with globally generated climate-driven erosion, major erosion in New Zealand resulting from local tectonic plate movements would also have damaged biota. If populations were close to their ceilings of sustainability this would have had a negative demographic impact. This is clearly the case for two major tsunamis with nationwide impact, dated by Roy Walters and James Goff [26] to AD 1220 and AD 1450, when Maori populations were high enough to have been threatened by a significant reduction of biota. The 1450 tsunami must have been especially catastrophic, occurring at a time when starvation, two generations after the descent of the Little

Ice Age, would already have been endemic. Direct destruction of crops by tsunamis may have occurred in some areas in addition to a nationwide destruction of biota consequent on erosion, salt water inundations and landslides from multiple fault ruptures.

James Goff and Bruce McFadgen [27] suggest that we need to add insights from recent studies of the tectonic history of New Zealand and a history of significant tsunami inundation to our understanding of the erosion history of New Zealand. Where Grant assigns major periods of river aggradation and coastal dune building to "changes in river systems caused by increased rainfall induced by changes in airflow and atmospheric warming over New Zealand" they argue that

> Recent palaeoseismic research, however, leads us to suggest that there may be a tectonic link. We propose that the Matawhero river aggradation event (Grant, 1985), the Ohuan Chronozone of coastal dune building (McFadgen, 1985) and the Kekerionean (coastal dune) Depositional Episode (McFadgen, 1994) form part of a sequence of environmental outcomes that were generated by a cluster of large earthquakes (pp. 2230–2231).

They identify a specific earthquake cluster: "At least five, probably large, earthquakes have been identified (there might be more) that relate to fault rupture around the 15th Century AD." And they conclude, after considering evidence relating to these earthquakes:

> If our model is correct, then the cluster of 15th Century AD earthquakes stands out as a New Zealand-wide catastrophe, causing tsunami, catastrophic erosion of hill slopes, river aggradation, rapid coastal dune building, and abandonment of coastal settlements. When viewed in the light of Holocene landscape change in New Zealand we consider that this, and possibly earlier and later clusters of seismic activity, should be recognized as a major driver of change in geomorphology, vegetation and human settlement (p. 2234).

Goff and McFadgen, further, link the 15th century event with a major El Niño in AD 1450, suggesting earthquake, tsunami and climate as concomitant factors triggering massive erosion in the mid-15th century.

A geo-environmental report prepared for the Wellington Regional Council [28] suggests how the environmental destruction caused through the warm-wet periods that Grant charts has been drastically reinforced by erosion caused by earthquakes and tsunami:

> In brief, seismic activity immediately generates tsunami and landslides. Sediment flow down rivers causes an increase in fine material reaching the nearshore zone and a period of rapid coastal dune building takes place, while coarser material forms river aggradation surfaces. Prehistoric coastal Maori settlements suffer from tsunami inundation, sediment smothering of shellfish beds, and loss of land due to landsliding and aggradation (Goff and McFadgen, 2001).

In AD 1450 the environmental destruction caused by an earthquake cluster and nationwide tsunami can only have intensified erosion and the loss of biota, aggravating climate-driven starvation and conflict over land and resources. Also inevitably it would have led to a nationwide destruction of archaeological evidence. Earlier earthquakes and local and nationwide tsunamis must also have destroyed archaeological evidence. Though smaller earlier populations, with much higher ceilings of sustainability, may not have been threatened by the loss of biota through erosion, earlier earthquakes and local and nationwide tsunamis will also have destroyed archaeological evidence.

Roy Walters and James Goff [26] provide a clear summary of palaeo-tsunami data dating back to about 6,300 years BP which provides some precise detail directly relevant to our argument for cumulative loss of archaeological evidence through erosion (pp. 145–146). Noting that "The 1450 'event' is most likely related to a number of tsunamis generated by a cluster of large earthquakes in the 15th century", they comment that evidence from archaeological sites shows "almost ubiquitous signal of inundation found throughout the country". In the case of Palliser Bay, they note that the tsunami of AD 1450 penetrated 3.5 km inland with "erosion of coasts for about 1.5 km landward". Given such extreme erosion, the hope of recovering archaeological evidence for the ancient settlement described in the traditional accounts of Maui the Navigator's meeting with the chieftainess at Orokoroko (see Chapter 16) is negligible. This is especially so given Walter and Goff's detailing of earlier tsunami with a comparable nationwide impact. One in AD 200 (a hundred years after Maui's visit) was generated by the Taupo eruption and other tsunami with nationwide impact occurred in AD 500, 950 and 1220. Though population levels before AD 1000 may not have been close enough to ceilings of sustainability for these events to have significant demographic impact, the cumulative erosion from these major tsunami greatly reduces the chances of piecing together the early coastal settlement history of New Zealand from archaeological evidence, as does the resculpting of landscapes that Grant describes through climate-driven erosion of hillsides and valleys and the creation of lakes through the accumulation of silt.

The seismically active character of New Zealand due to the interface between the Australian and Pacific plates, evidence for recurrent clusters of earthquakes both terrestrial and submarine, for tsunamis and for volcanic eruptions triggering landslides have clearly played a part in shaping the erosion history of New Zealand. An inevitable loss of archaeological evidence reaching back to first settlement can sensibly be assumed. All such catastrophes must inevitably have impacted on the biota in the short term at least. The earthquake cluster and major tsunami of AD 1450 will have impacted on Maori food resources through the smothering of shellfish beds, the destruction of forest and reduction of fish stocks and through damage to gardens through salt inundations and the encroachment of sand. The cumulative destruction of forest foods and fish stocks through cold and catastrophic tectonic and volcanic events and a nationwide tsunami expand the picture of climate-driven demography we have been painting – reinforcing our demographic argument for starvation and conflict and drastically falling Maori populations in New Zealand after AD 1400.

In his recent book, *Hostile Shores: Catastrophic Events in Prehistoric New Zealand and Their Impact on Maori Coastal Communities* [29], Bruce McFadgen argues for a significant loss of life for Maori in the tsunamis of c. AD 1450. He correlates major loss of life with a loss of technological sophistication in adze-making and in canoe-building in New Zealand caused, he suggests, by the drowning of experienced craftsmen. A change to locally sourced stone from varieties traded before the tsunamis over considerable distances he attributes to the drowning of coastal-dwelling canoe-builders and navigators.

There can be little doubt that the 1450 tsunamis had a devastating impact on food resources with a consequent escalation of starvation and conflict over land and resources. Losses of skills and expertise and knowledge are to be expected in any society suffering severe demographic loss. Some population losses may well have followed directly from the catastrophic earthquakes and tsunamis of the mid-15th century but this alone is unable to account for major population decline in 15th century New Zealand. There is skeletal evidence establishing low life-expectancy and severe population decline covering the 600-year period from AD 1180 to AD 1769 to which the skeletons belong. This evidence will be studied in Chapter 14. A 600-year demographic decline suggests the primacy of climate-driven population losses undoubtedly amplified by losses through the nationwide tsunamis of AD 1220 and AD 1450.

How many would have been drowned in these tsunamis is unclear. The correlation between tectonic and volcanic activity and tsunamis must have been well known to Maori. Amongst coastal tribes, recognizing signs of an impending tsunami must have been part of traditional knowledge vital to survival. Maori dogs may well have headed to high ground well ahead of a tsunami, as dogs in Japan do today, effectively giving a tsunami warning to coastal tribes. A ten-year-old English schoolgirl, holidaying in Indonesia at the time of the 2004 tsunami, reputedly saved hundreds of lives by recognizing the rapid retreat of the tide that precedes a tsunami and persuading people to leave the beach. A school project gave her the knowledge to save herself and many others. Kevin Krajick [30] notes that while up to 300,000 people are thought to have died in the Indian Ocean tsunami of 2004, "the indigenous seafaring Moken people of Thailand almost all survived. Their traditions warn that when the tide recedes far and fast – as happens before a tsunami – a man-eating wave is coming and everyone should run. They did."

Passing on knowledge relevant to survival is of course one of the major roles for tradition. Knowledge relating to impending earthquakes and tsunamis must have been carefully preserved and transmitted in a country where recent research estimates nationwide tsunamis can be expected to occur every 500 years [26].

It is easy to see how the devastating cumulative destruction of biota caused by both wet erosion periods, the extreme cold of the Little Ice Age and by two tsunamis in 1220 and 1450 with nationwide impact, would have created a demographic crisis in Little Ice Age New Zealand. In the next chapter we draw on evidence relating to Maori pa, derived both from early European accounts of pa and from modern field archaeology, to establish that even in the richest areas there were massive population losses in New Zealand during the Little Ice Age. In Chapter 14 we show through statistical analysis of skeletal evidence that in the Little Ice Age the demographic crisis faced in New Zealand was perhaps as extreme as that anywhere else in the world.

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Chapter 13
The Context of Field Archaeology: The Maori Pa

Abstract Evidence is gathered from early European accounts and from modern field archaeology to illustrate the numbers, density and population capacity of Maori pa (hill-forts). This evidence reveals the scale of pa-building in horticultural areas, the density of pa in the landscape, the very considerable population capacity of both large pa and of pa large enough to be described as citadels and the importance of pa in defending horticultural land, stored harvests and access to harbours and rivers and so to marine and estuarine resources. Both early European and Maori accounts report pa capacity greatly in excess of Maori populations at the time of European contact and link this to population decline. The material presented in this chapter provides a necessary and enriching background to the archaeological and demographic evidence we consider in the following chapters. That evidence and its interpretation are central to our demographic argument for a very early first settlement of New Zealand.

Keywords New Zealand field archaeology · Pa capacity · Indonesian origins of pa · Prehistoric populations

13.1 Introduction

In Chapter 11, challenging the claim for a late first settlement of New Zealand, we demonstrated the excess of pa capacity when viewed in the accepted frame of an increasing population, an assumption basic to a theory of late first settlement. We showed that estimates of Maori population in New Zealand at the end of the 18th century, when viewed as peak or near-peak populations, are incompatible with evidence for pa capacity. In this chapter we consider evidence from early European accounts of Maori pa and from modern field archaeology as to the numbers, density and population capacity of pa. These accounts support our argument for drastic population loss during the Little Ice Age. The material presented in this chapter provides a necessary and enriching background to the archaeological evidence we consider in the next chapters. That evidence and its interpretation are central to our demographic argument for a very early first settlement of New Zealand.

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13.2 Evidence from Early European Descriptions of Maori Pa

To give some idea of the scale of Maori pa and of their impact on the landscape, we present some of the early European descriptions of pa collected by Elsdon Best in his book *The Pa Maori* [1]. This book has been described by Janet Davidson as "a monolithic foundation to New Zealand field archaeology" [2].

Many early Europeans describing pa comment on the evidence for much higher earlier Maori populations implicit in the size and population capacity of pa and implicit in the abandonment of associated horticultural land. Some Europeans had had their opinion of substantial population loss confirmed in discussion with Maori.

Janet Davidson [3] suggests that pa-building was the greatest focus for labour expenditure in prehistoric New Zealand of any activity, including canoe building. Early European descriptions of Maori pa confirm this. Best, for example, quotes Colonel McDonnell's account of a pa known as Ka-rewa-ki-runga, situated on the left bank of the Hokianga, about 20 miles from the Heads:

> A high hill, the summit of which had, after great labour and skill, been fashioned by many hundreds of pairs of hands into a formidable pa, hewn out of solid earth. It was the principal stronghold of the settlement. . .It would probably have taken five hundred navvies, working with pick, shovel and barrow, twelve months hard work to cut down and form this work; but when one knows that all the tools with which this work was undertaken, and accomplished, were only bits of hard wood, pointed and burnt hard in a fire, and the only means of carrying away the thousand tons of earth, stones and gravel, were small buckets made of flax, one is forced to admire the courage and perseverance of the Maori of those days (p. 168).

The enormous labour involved in constructing a large pa and the numbers needed to defend it imply very significant populations in the areas where they were built. Many early European observers commented on the numbers of pa often crowded into one area. Best, for example, quotes F.H. Bodle:

> In writing of the Hauraki Gulf, Mr F. H. Bodle has remarked that the shores of the lower part of the gulf show the remains of a great number of old pa: – "At one time this gulf shore must have supported an enormous aboriginal population. Every hilltop, every point of advantage, is carved and terraced into forts and watch-towers, not only along the coast, but for miles inland. Not only this, but every foot of valley land was dug and drained, and the stones carefully removed and piled in heaps" (p. 3).

Modern prehistorians have talked about the surprising density of pa in some areas. In 1970 L.M. Groube [4] claimed there was an overall density of one to every 4–6 square miles below the 1,000-ft contour and more than one per square mile in favoured areas.

To give the reader some idea of the numbers of pa and the "great size of some of them" Best quotes from Maning's *Old New Zealand*:

> The natives are unanimous in affirming that they were much more numerous in former times than they are now, and I am convinced that such was the case, for the following reasons. The old hill forts are many of them so large that an amount of labour must have been expended in trenching, terracing, and fencing them, and all without iron tools, which increased the difficulty a hundred fold, which must have required a vastly greater population to accomplish than can be found now in the surrounding districts. These forts are also of such an extent that, taking into consideration the system of attack and defence used necessarily in

> those times, they would have been utterly untenable unless held by at least ten times the number of men the whole surrounding districts, for two or three days journey, can produce; and yet, when we remember that in those times of constant war, being the two centuries preceding the arrival of the Europeans, the natives always, as a rule, slept in these hill forts with closed gates, bridges over trenches removed, and ladders of terraces drawn up, we must come to the conclusion that the inhabitants of the fort, though so numerous, were merely the population of the country in the close vicinity. Now from the top of one of these pointed, trenched, and terraced hills, I have counted twenty others, all of equally large dimensions, and all within a distance, in every direction of fifteen to twenty miles; and native tradition affirms that each of these hills was the stronghold of a separate clan, bearing its distinctive name. There is also the most unmistakeable evidence that vast tracts of country, which have lain wild time out of mind, were once fully cultivated. The ditches for draining the land are still traceable, and large pits are to be seen in hundreds, on the tops of the dry hills, all over the northern part of the North Island, in which the kumara were once stored. . .These pits, being dug generally in the stiff clay of the hill tops, have, in most cases, retained their shape perfectly, and many seem as fresh and new as if they had been dug but a few years. . .

> Another evidence of a very large number of people having once inhabited these hill forts is the number of houses they contained. . .Now in two of the largest hill forts I have examined. . .the houses had been arranged in streets, or double rows, with a path between them, except in places where there had been only room on a terrace for a single row. The distance between the fireplaces proved that the houses in the rows must have been as close together as it was possible to build them, and every spot, from the fort to the hill top, not required and specially planned for defensive purposes, had been built on in this regular manner. Even the small flat top, sixty yards long by forty wide, the citadel, had been as full of houses as it could hold, leaving a small space all round the precipitous bank for the defenders to stand on (pp. 25–26).

Best collected information on the great size of many of the pa:

> Mr Colenso wrote as follows of the Whakawhitira pa, a fort that was said to have held 2,000 men:

> Its fence [stockades] was also threefold, the massy and combined outer one being twenty-five to thirty feet high; its main posts consisting of entire and straight trees denuded of their bark, with large carved full length figures painted red on their tops; of these figures there were above a hundred. During our stay there we measured, by stepping, one of the sides of this pa, and found it to be more than a mile in length, and the huge carved figures we ascertained to be more than six feet high, with their heads fully and deeply tattooed (p. 28).

The hundred tattooed heads is a remarkable detail, the labour involved astonishing, especially given that the posts would have been hardwood and the chisels of stone. It suggests the psychological importance of these figures as a deterrent to attack. There is, too, a clear connection between carved figures such as these on Maori palisade posts and those on palisade posts in Borneo. The connection is remarkable enough to suggest a very ancient, possibly even a Lapita, origin for this Maori practice, since it is matched in eastern Indonesia (Figs. 13.1 and 13.2). Best quotes Ling Roth:

> Some of the tribes of Borneo protected their communal houses by means of stockades. These defences consisted of a double row of palisades. Many of the poles of which it consists are ironwood, sometimes 30ft high, with rough carvings, representing disfigured [grotesque] human faces with long tongues. . .in order to frighten as it were the attackers (p. 431).

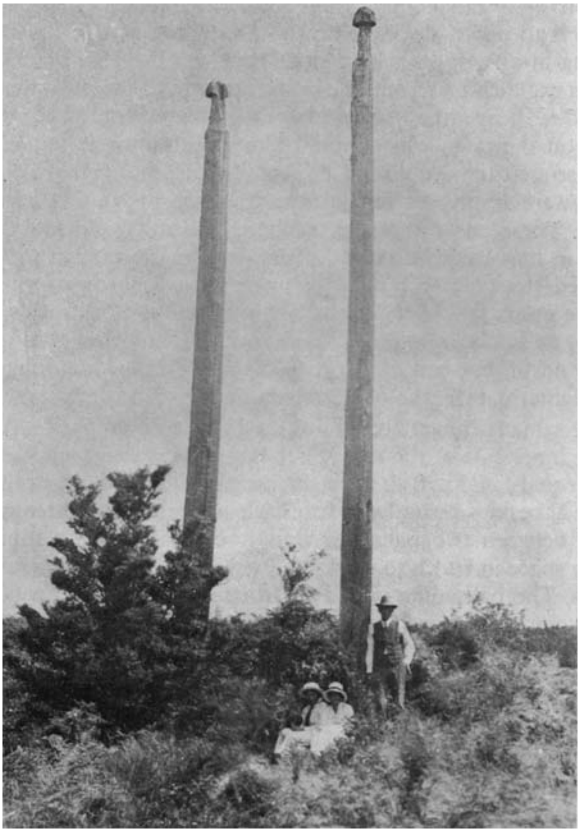

Fig. 13.1 These two posts suggest the unscaleable height of the palisade to which they belonged

One thinks immediately not only of the figures on top of Maori pa palisades, but also of the famous battle haka of Maori. Its purpose to frighten the enemy, the haka, was performed by warriors with protruding tongues, battle cries and battle postures.

Best gives other examples of huge pa. For example, he quotes Canon Stack as saying that at Mairangi and Kapuka-riki the remains of a walled pa extended for about 3 miles along the downs, quotes another writer as saying that the Maunga-kiekie pa on One Tree Hill covered 100 acres and could accommodate thousands and refers to another source as saying that Otatara near Taranaki extended over 80 acres.

Best mentions also a pa seen by Wakefield in 1839 with outer stockades at least a mile in circumference, three forts at Tapa-hurau said to have held 1,000 each, a fort at Mangere with 3,000 inhabitants and a fort on the banks of the Waipaoa River at Poverty Bay whose only fault was the amazing extent of ground it covered because it would require from 2,000 to 3,000 men to protect it. Indeed, Best describes more than 16 pa able to hold a thousand or thousands (pp. 26–38).

The very existence of pa of such great size and in such numbers, we believe, is indicative of the conflict over land and resources that erupted with the extreme cold

Fig. 13.2 Otatara Pa. The population capacity of this pa is clear: every wrinkle in the landscape represents a terrace on which a house or houses once stood. Reproduced with permission from NZ Aerial Mapping Ltd

conditions of the Little Ice Age. This conflict was triggered, we have suggested, as the pressure of high populations impacted on ecological systems and reduced the biomass, lowering ceilings of sustainability for all species, in some cases, as with the moa and many birds, inducing extinctions. Europeans tended to see the obvious evidence for massive population loss in reduced or abandoned pa as due only to epidemics of European diseases. Best, describing Pouera, the volcanic cone pa of the far north, inland of the Bay of Islands, for example, comments:

> This famed hill fort must have accommodated a vast number of natives, and many were living there when Archdeacon Williams remembered seeing 1,400 natives living on the eastern slope alone of Pouera, but at some time in the past a very much greater number must have occupied this hill (p. 304).

In *The Maori*, Vol 2 [5], Best, discussing this pa, adds, “The epidemics introduced by early vessels had probably accounted for the rest.” From evidence already presented, and from that to be presented in the next chapter, we shall see that climate-driven population loss in the Little Ice Age before European contact was, in fact, largely responsible for the reductions in pa populations and the abandonment of pa and associated horticultural land that the early Europeans recorded.

13.3 Evidence from Field Archaeology

Davidson [6], looking at the question of when pa-building became important, believes that "the evidence is still inadequate to answer this question". She quotes the work of Groube and Mihaljevic, though she is dubious about their demographic assumptions:

> Groube reviewed various models of population growth in prehistoric New Zealand and considered the amount of time people might spend building or rebuilding fortifications. He concluded that by the fourteenth century the population might already have achieved a relatively high proportion of that existing in A.D. 1800. He postulated a sudden and rapid efflorescence of fort building thereafter. . .Milhaljevic, following a similar approach to that of Groube, suggested that the maximum prehistoric population was reached by A.D. 1200, and maintained thereafter by cycles of warfare.

Davidson goes on to consider some archaeological evidence for dating:

> About twenty pa have been radiocarbon dated. Even if the oldest dates for each site are accepted, none of these pa is more than about 500 years old. . .Some of the earliest dates for "pa" are for sites which may not actually have been fortified at the time, or if so, depended on palisades, or palisades and scarps, rather than ditches. Examples are the Auckland volcanic cone sites of Mount Wellington and Mount Roskill, and initial occupation of the swamp pa of Oruarangi in the Hauraki Plains. Early use of defensive ditches is seen at Kauri Point and Te Awanga. Unfortunately, neither is precisely dated, and the ditches may have been built at any time between the late fourteenth and sixteenth centuries. On the whole, A.D. 1500 is a reasonable estimate for the appearance of ditches. The fighting stage preceded the use of a substantial ditch at Otakanini, but the two appeared together at Te Awanga. Thus the various defensive devices observed in the late eighteenth century have a history of at least 300 years, and their origins appear to lie in the period between A.D. 1300 and 1500. The final development of prehistoric fortifications was a progressive strengthening of the ditches and palisades, and sometimes the addition of a second ditch. The third and final stage of the Kauri Point defences in the eighteenth century involved a double ditch (p. 193).

Davidson, 3 years later [7], comments:

> Dates for paa, with two possible exceptions, still do not go back beyond the 15th century. Taking these 15th century dates back to their earliest limit at two standard deviations we just touch A.D. 1300. In most areas there seems to be a fairly even spread from the 15th century to the period of less than 250 years. Irwin's Pouto study stands out against this pattern, with its preponderance of relatively recent dates for paa. (Ten out of 13 dates were less than 250 years before present.)

We note that both the Pouto pa and pa built in northern Taranaki in the 17th century were built to defend newly developed horticultural land.

Ten years of careful, detailed field archaeology in the Bay of Plenty, carried out by K.W. Moore for the New Zealand Archaeological Association's site recording scheme, offers an additional perspective to the vivid descriptions of Maori pa presented in Best's pioneering volume. Using this data, Aileen Fox [8] analyses the distribution of the recorded Maori sites in the bay in relation to topography:

> This was the territory of the Te Arawa and Urewera tribes in the later prehistoric times, with a probable divide on the Rangitaki river and the swamps... The outstanding feature

> of the distribution (fig. 60) is the constant and close relationship between the occupation sites and the water; the sea, the harbours, the lakes, and the rivers. The remarkable coastal concentrations are slightly overweighted by the inclusion on the map of beach midden sites of all periods but there are many pa on the hills immediately behind the shore. Each of the inland lakes in the Rotorua area has fortifications on its margin, though their hinterland is practically blank. In the eastern half of the area, it is clear that the occupation was confined to the coastal belt and that the limited penetration of the mountain ranges was along the flanks of the valleys as in the Ruatoki area or the Waiotahi and Waioeka rivers. In general there are few pa above 300 metres and the majority are found below 150 metres. . ..the Maori, lacking domestic animals other than a dog, relied for protein in his diet primarily on a variety of fish, together with eels and shellfish, supplemented by birds and some sea mammals. Most of these were obtained from the coasts, especially the shallow harbours like Ohiwa and Tauranga in this area, but also from the lakes and the rivers. . .A pa was built within reach of a good source of food supply.

Fox comments that in many areas the pa are very close together, "often clustering within half a kilometre, sometimes only a few hundred metres apart", and that in such cases "Coexistence seems unlikely." She suggests replacement may be an explanation when, for example, a pa has been made *tapu* (sacred and therefore unavailable for common use) by the shedding of relatives' blood. (Best notes *tapu* may also follow the burial of a chief at the site.) Fox suggests that replacement was probably a widespread custom [9] but later contradicted this conclusion [10], remarking that most pa were occupied for several hundred years.

An alternative argument for pa density is that it may reflect a tribal settlement pattern, in which *hapu* (sub-tribes) live in smaller pa close to the major pa which effectively act as citadels. *Whanau* (family groups) may live in undefended settlements nearby, knowing they can seek refuge in nearby pa or in a tribal fortress at need. Their help in defending pa would in turn be useful to the tribe.

The escalation in the building of additional defensive strategies during the Little Ice Age suggests an intensification in the ferocity of attacks driven by starvation. The coldest centuries during the Little Ice Age appear to be AD 1400–1500 and especially AD 1600–1700. Population losses from cold-induced starvation and warfare in these centuries, given the dating Davidson suggests, may have triggered the addition of defensive strategies to new pa and the rebuilding of old pa to accommodate additional strategies. But commonsense suggests that, given a context of falling populations and given the enormous labour involved in constructing pa and the numbers needed to man them, the majority of large hill-forts visible still in New Zealand today will have been constructed and first manned when the population was still very large, perhaps in the first two generations after the onset of the Little Ice Age in AD 1400.

In Chapter 15 we suggest that, in the context of falling populations, a sequence of additional fortifications would also have provided a solution to the problem of securing protection against attack given drastically declining populations. In Chapter 14 we argue that the "half-life" of the pa was about 107–108 years – that is, the number of defenders halved every 107–108 years. With sequential fortifications, each additional defensive strategy would have made it easier for the pa to be defended by half the number of warriors. This is discussed in more detail in Chapter 15.

The sequence of fortifications adopted probably varied from pa to pa. Perhaps first adding a scarp (a steep downwards incline outside the outer palisade) would have made it harder to attack the outer defences. Adding a terrace within the pa would have enabled the defenders to throw projectiles over the palisade. Constructing transverse ditches, creating a deep ditch on the outside of the outermost palisade in place of a scarp, then coupling further palisades with further ditches and finally building fighting stages for defending the higher outer palisade would be likely later stages in the fortification sequence.

13.4 Maori Pa in the Context of Falling Populations

In Little Ice Age New Zealand, pa, according to size, can be seen as citadels, fortified towns or villages. Oral traditions in New Zealand suggest that in some areas permanent occupation of pa may not even represent a recent change in use. For example, in the story of Hoaki and Taukata and the coming of kumara to New Zealand (which in Chapter 19 we date to about AD 1200) it is clear that the tribe, led by Tama-ki-Hikurangi, which the Tahitian brothers visit, are living in their pa rather than using it as an occasional refuge. Over 200 years earlier, Toi built his famous pa, Kupu-te-rangi, which Percy Smith tells us, was “situated on a peak of the range lying about half-a-mile to the east of the modern township of Whakatane” [11]. Traditional evidence establishes that this pa was built by Toi to protect his newly arrived men from the indigenous peoples already occupying the district. Toi’s need seems to prescribe continuous rather than occasional use, and this may well have been true for the many pa built by migrants arriving in New Zealand from Eastern Polynesia in the Medieval Climatic Optimum. Even though, for safety, Polynesian migrants would have had little option but to marry into indigenous tribes, their permanent occupation of pa, an additional safety measure, could have become commonplace in the better districts from the beginning of the Medieval Climatic Optimum. Canoe histories relating to the last migration from Eastern Polynesia make it clear that building a fortified settlement was the first task for these migrants. If, as Davidson suggests, the earliest pa were simply defended by palisades and scarps, they would not be as archaeologically visible as the later Little Ice Age forts, with their massive terracing and ditches, to say nothing of post holes for 30-ft-high palisades.

13.5 Indonesian Origins for New Zealand Pa?

Neolithic hilltop forts worldwide share engineering features, most notably ramparts, ditches and palisades. There is no doubt that building pa in New Zealand was an indigenous practice. There are, however, details of fortified villages from Sumatra and Borneo that suggest the possibility of a long-remembered tradition lying behind the detailed construction of the Maori pa, a tradition perhaps going back to Lapita times. Elsdon Best quotes Nicholas on the similarity of Maori customs with those of the Battak people of Sumatra: "In the fortified villages of these people, we see almost an exact description of the New Zealand pa." More significantly, he quotes Ling Roth's description of forts in Borneo, already mentioned with grimacing heads on 30-ft-high palisade posts. The details Roth supplies are too idiosyncratic to be classified merely as being characteristic of Neolithic hill-forts.

Best adds that Roth also mentions "a stage or elevated platform inside the stockades, from which an attacking force was harassed". There are other precise structural details from forts in New Guinea that Best draws attention to: "Haddon's statement concerning the upward sloping stages secured to the upper part of the stockades of fortified places of New Guinea, is of interest for such stages formed a marked feature of our pa maori of New Zealand" (p. 431). Best also mentions the use of tree houses within the palisades used as stages and quotes examples of this practice in New Zealand, and describes openings to forts in New Guinea closed by horizontal sliding bars, also a feature in the Maori pa (p. 431).

These idiosyncratic details together with the whare wananga discussion of the best kind of pa for the migrants to build in Borneo, quoted in Chapter 5, suggest an ancient continuing tradition in fort construction in Borneo, Sumatra and New Guinea that may have been preserved in the detail in New Zealand pa. Perhaps these traditions were remembered and put into practice when growing populations, declining resources, the arrival of migration canoes in the Medieval Climatic Optimum from Eastern Polynesia and starvation in the Little Ice Age threatened tribal security. Remembered defensive practices, given an ancient homeland in the Spice Islands, gives credence to such a possibility.

13.6 Deflated Estimates for Prehistoric Populations

To conclude this chapter, we present some observations on New Zealand palaeodemography made by the geographer Gordon Lewthwaite in 1999 [12]. Lewthwaite comments that over the last 50 years he has noticed a "general acceptance of deflated estimates" for the New Zealand population at the time of Cook's voyages. He comments on the neglect of some higher estimates for the New Zealand population which were made at first contact. He notes neglect of population estimates made by missionaries and early settlers and of contemporary challenges to Cook's estimate of 100,000. He comments also on late 20th century reductions of 19th century census estimates and of modern neglect of 19th century estimates for population losses in wars and epidemics which imply larger earlier populations than modern demographers seem prepared to accept.

Accepting higher pre-contact and early 19th century population levels, of course, presupposes higher population growth rates if a late first settlement is envisaged. It is unclear whether the process of deflation that Lewthwaite notes was a consequence of the claim in the last decade of the 20th century for a 12th century first settlement of New Zealand or if it led to that claim. It is perhaps not coincidental that Anderson's paper arguing for a 12th century first settlement was published in the same year that

Pool rejected his 1977 estimate of 125,000–175,000 for the prehistoric population at Cook's arrival. In 1991 Pool claimed that it had become "impossible to envisage a population size much above 110,000 to 115,000 in 1769. An argument suggesting 200,000 or greater would be particularly difficult to support" [13].

Lewthwaite's comments on the population estimates made by naturalists aboard *The Endeavour* are interesting. He reports the observations of J.F. Forster, naturalist on Cook's second voyage (1772–1775) and of his son Georg, and of Joseph Banks, naturalist on the first voyage (1768–1771). He quotes Banks' conclusion that "the sea coast was inhabited and that but sparingly, insomuch that the number of inhabitants seemed to bear no kind of proportion to the size of the country" and Banks' attribution of this to "their frequent wars". He sees echoes of Banks' phraseology in Georg Forster's affirmation that the North Island "on a coast of near four hundred leagues, contains scarcely one hundred thousand inhabitants". He records Georg Forster's father's noting "very few inhabitants" in the South Island and his alluding to "the account we had from Captain Cook, and from what we saw in some few places" which led to the estimate of "100,000 souls in both isles", though he felt this seeming consensus fell rather "short of the true population".

Lewthwaite cites factors he believes led to the naturalists' underestimations of the New Zealand prehistoric population:

> Banks was correct in presuming emptiness for most of the South Island, but in the North even the shorelines concealed much that navigating eyes could not perceive. Cook, zigzagging his storm-tossed way south from the North Cape saw only long lines of dunes, writing "The Desert Coast" over a shoreline indented by the populous harbors of Hokianga, Kaipara, and Manukau, whereas only occasional fires or canoes gave hint of habitation near the Waikato coast or Taranaki bluffs. Banks, underscoring even shoreline sparseness, added that "beside this the whole Coast from Cape Maria Van Diemen to Mount Egmont and seven-eights of the Southern Island seems totally without people." And what could seafarers know of inland sites within Northland, along the Waikato and Whanganui rivers, let alone those by the inland lakes of Rotorua, Taupo, and Waikaremoana?

Lewthwaite shows that modern population estimates are at odds with early European population estimates and also at odds with 19th century estimates for population losses from wars and epidemics which imply far higher earlier populations:

> As Bonwick expressed it in a simple geography text in 1856 – just before the first official Maori census – the population of Cook's time "is thought to have been at least half a million, but exterminating wars, and raging epidemic diseases" had cut the number to one-fourth. Archdeacon Walsh, underscoring populous districts unseen by Cook, the multiplicity of empty forts, and the "immense area" bearing traces of former cultivation, envisaged total numbers "not at one, but at many hundreds of thousands," a total since halved by "the inevitable chain of causation" that followed European contact.

Lewthwaite concludes:

> Time-frames and statistics may vary, but similar thoughts appear in G. Mair's estimate that Hongi Hika's wars (1822–1837) alone cost 40,000 lives, in Colenso's view that deaths from 40 years of war before 1840 "far exceeded 60,000," that one epidemic destroyed almost three-fifths in the southern North Island, and S.P. Smith (cofounder of the Polynesian

Society), in a study of Maori wars, accepted as sound the missionary judgment that the first third of the century saw population decreased by 80,000 due to “war, famine, and their accompaniments”.

Even though they were made by contemporary observers, these 19th century estimates are so at variance with modern thinking that it is not surprising that they have been rejected by modern prehistorians and especially by those championing a 12th century first settlement. In Chapters 14 and 15 we explore rigorous modern approaches to New Zealand palaeodemography which avoid many of the confusions, contradictions and pitfalls that have bedevilled New Zealand palaeodemography. Such problems, we show, have all sprung from a failure to recognize extreme climate-driven population losses in New Zealand in the Little Ice Age which meant that population estimates made by those on *The Endeavour* were not of maximum populations. In Chapter 14 we present a revised analysis of skeletal evidence which provides explicit, quantifiable evidence for drastically falling populations in the Little Ice Age and thereby establishes both that the populations that Cook estimated were remnant populations and that there must have been high populations in New Zealand at the beginning of the Little Ice Age.

The climate-driven palaeodemographic history revealed through modern statistical analysis in Chapter 14 and even more clearly through power law analysis in Chapter 15 throws emphasis onto New Zealand’s long demographic history. We are able to provide estimates for the climate-driven population losses in the Little Ice Age. From these it is clear that variations in estimates for the total New Zealand population at the time of Cook and in 1801, variations proposed to 19th century census estimates and variations in estimates for population losses due to epidemics and wars in the 19th century at most can only alter by a few per cent estimates for the extreme total population losses incurred by Maori from the beginning of the Little Ice Age to 1896. The controversies that have been so prominent in New Zealand palaeodemography appear less relevant when placed in a global climate context and in a much longer demographic time frame.

In summary, we have sought in this chapter to represent the massive scale of pa-building in horticultural areas, the density of pa in the landscape, the very considerable population capacity of pa large enough to be described as citadels and the importance of pa, large and small, in defending horticultural land, stored harvests and access to harbours and rivers and so to marine and riverine resources. That 98% of pa were built to defend horticultural land, we have argued, suggests that in the Little Ice Age horticulture was seen as a prime insurance against starvation in a time of extreme resource depletion. In this chapter we have reported European and Maori interpretations of pa capacity greatly in excess of Maori populations at the time of European contact as evidence of extreme population decline during the Little Ice Age. In Chapter 12, as evidence of widespread starvation, we drew attention to the extinction of bird species and the diminishing numbers of seals in the Little Ice Age and to the apparent abandonment of traditional hunting protocols designed to protect against over-hunting and species extinction. And we argued that starvation was implicit both in the appearance in the Little Ice Age of cannibalism in New Zealand

and in the building of pa to protect agricultural land and stored harvests. In the next chapter, we present statistical and archaeological evidence for extreme population losses in the Little Ice Age.

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Chapter 14
New Zealand Palaeodemography: Archaeologically Based Demographic Evidence

Abstract Modern statistical analysis of the skeletal evidence studied by Brewis, Molloy and Sutton in 1990 gives explicit quantifiable evidence for drastic population loss in the poorer areas in Little Ice Age New Zealand. Using new evidence from field archaeology relating to Maori pa (hill-forts) it is possible to estimate the total population capacity of pa in AD 1445 and to use this with Rutherford's and Urlich's population estimates for 1801 to determine differential rates for population decline in the pa areas and in poorer areas. Combining these approaches makes it possible to offer a comprehensive overview of the demographic patterns shaping the prehistory of New Zealand in the Little Ice Age. That the differential in population decline rates between pa and non-pa areas is so great highlights the efficacy of growing and storing kumara to combat starvation. That is, it supports the role of horticulture and pa-building as strategies for survival. The demographic evidence presented in this chapter for drastically falling populations in the Little Ice Age establishes definitively that a late first settlement date for New Zealand is out of the question.

Keywords New Zealand palaeodemography · Little Ice Age · Pa areas · Non-pa areas · Population decline

14.1 Introduction

The claim for a late first settlement of New Zealand implies a rapid and sustained population growth not just during the Medieval Climatic Optimum but also, and against world patterns, in the Little Ice Age. Making a case for the Lapita-age first settlement of New Zealand that is predicted by our central paradigm requires an engagement with fundamental demographic issues. In this chapter we use modern statistical methods to derive new parameters from the skeletal data studied by Alexandra Brewis , Maureen Molloy and Douglas Sutton in 1990. Our new analysis provides clear and quantifiable evidence for drastic population losses during the Little Ice Age. By implication it establishes high population levels at the beginning of the Little Ice Age and a long demographic history for Maori in New Zealand.

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Palaeodemography is concerned with such issues as estimating demographic parameters from past populations (primarily from skeletons in an archaeological context) and/or making deductions regarding the health of individuals in those populations. The most basic parameters are age-specific fertility in women and age-specific survival rates of both sexes, from which life tables can be constructed.

Osteologists face considerable problems with the development of reliable age indicators in skeletons which can be used to relate skeletal morphology to chronological age. The determination of age-specific fertility rates for women depends on the fact that macro-anatomical alterations may occur at the pelvic bone, in the form of pitting, as a consequence of pregnancy and childbirth. The number of pregnancies/births may be estimated from what is variously described as pitting or scoring at two sites, the posterior pubic symphysis and the preauricular groove of the ilium. Age-specific fertility rates are then derived by relating the total number of pregnancies/births over the life of a woman to her age at death. This method is not without difficulties. Pitting can arise in nullipara and, further, its traces can gradually become less pronounced over the years following a birth. A computer simulation study by Brewis [1], however, tended to confirm osteologically based estimates.

There are further difficulties in the use of statistical techniques for handling both indicators relating to survival rates and indicators relating to fertility rates. A good account of some of the ideas, techniques and problems is provided in Hoppa and Vaupel [2].

14.2 New Zealand Palaeodemography

Because of endemic problems with the preservation of prehistoric skeletons in New Zealand, palaeodemography has been limited to studies of Maori skeletons from disparate times and locations. Estimations of fertility in prehistoric New Zealand have been made by Houghton [3], Phillipps [4], Sutton [5] and Visser [6]. Progress has been aided by studies by Houghton [7] of scoring of pelvic bones. Estimates of average age at death were given by Houghton [3] and by Simpson [8] and Sutton [9]. The most detailed New Zealand palaeodemographic study published to date, by Brewis, Molloy and Sutton [10], builds on the above. It called on an unusually large cohort of 172 skeletons.

As the authors note, when their study was published, the date of first colonization was widely believed to be AD 750–950. As we have seen, this date has since moved some centuries towards the present, with current wide acceptance of Atholl Anderson's claim in 1991 for a 12th century first settlement [11]. This claim was supported by his dismissal of the numerous radiocarbon dates, indicating earlier settlement, on the grounds of a lack of adequate chronometric hygiene. We have argued that a late settlement requires unrealistically high population growth rates to reach the population estimates of 155,000 and 166,000 in 1801, at the dawn of European settlement, made by John Rutherford [12] and of 175,000 made by Dorothy Urlich [13]. For a modest initial number of settlers (prehistorians usually posit only 50 or so), a very rapid and sustained population growth is required to meet these estimates. Even assuming an initial population of 300 in AD 1200, the 155,000 figure for 1801 corresponds to an improbably high average rate of growth of 1.045% p.a., while the 175,000 figure gives 1.065% p.a. As we have stressed, these improbably high population growth rates would have to be sustained, against global trends, during the Little Ice Age.

Even with a first settlement in AD 750, a group of 300 migrants would still need growth rates of between 0.596 per annum and 0.608% per annum to reach the estimated 1801 levels.

What light does the demographic work of Brewis et al. shed on Anderson's late settlement claim? The abstract to their paper records the implausibility of an earlier first settlement date of AD 750–950:

> Skeletal and comparative evidence of mortality is combined with fertility estimates for the precontact Maori population of New Zealand to determine the implied rate of precontact population growth. This rate is found to be too low to populate New Zealand within the time constraints of its prehistoric sequence, the probable founding population size, and the probable population size at contact. Rates of growth necessary to populate New Zealand within the accepted time span are calculated. The differences between this minimum necessary rate and the skeletally derived rate are too large to result solely from inadequacies in the primary data.

The authors proposed four alternative explanations:

(i) the skeletal evidence of mortality is highly inaccurate;
(ii) the skeletal evidence of fertility severely underestimates actual levels;
(iii) there was very rapid population growth up to AD 1150 for which no skeletal evidence is currently available;
(iv) the prehistoric sequence of New Zealand may have been longer than generally accepted.

After some discussion, Brewis et al. concluded that a combination of the last two was the most probable.

Brewis et al. found a population *decline* of 0.414% p.a. in association with a low infant mortality rate of 0.035. In a sample of 172 individuals, there were 6 infant deaths and 141 individuals reaching age 15. This corresponds to $p = 141/172$ where p denotes the probability at birth that a woman will live to age 15 or more. Considering the likelihood that infant deaths were under-represented by 24, Brewis et al. concluded that infant mortality would have been 15.3%, corresponding to $p = 141/196$. Examining this scenario, the authors obtained a corresponding population *decline* of 1.52% p.a., a rate more than three times the already high rate of 0.414% obtained from the skeletal analysis. Unaware of the climatic factors causing severe population losses globally during the Little Ice Age, which may have explained and validated their results, they rejected their own findings, although they could find no flaw in their approach or analysis.

Faced with the problem of a decreasing population, Brewis et al. proceeded to calculate, without reference to the skeletal evidence, the population growth rate needed to reach a population of 150,000 at the time of Cook (a figure in the interval 125,000–175,000 suggested by the demographer Ian Pool in 1977 [14]). In light of (iii) and (iv) they suggested the unrealistically high population growth rate of 0.875% p.a., sustained over 919 years, as feasible in the context of the then current thinking about prehistoric demography in New Zealand. They offered this unsupported increase rate of 0.875% p.a. in place of their own demographically derived decrease rate of 0.414% p.a..

14.3 Assumptions in Brewis et al.

In this chapter we readdress the issue of the growth rate of prehistoric New Zealand, employing modern statistical techniques to obtain refinements of the results obtained by Brewis et al. and in particular to derive confidence intervals for point estimates of rates of change in order to put analysis on a secure footing. We begin by examining the assumptions underlying their analysis.

In their analysis Brewis et al. employed a life table approach based on inferences from skeletal data providing information on ages at death and the total number of children produced by a woman during her life. The authors utilized the following assumptions:

(i) except for infants, the distribution of age at death as indicated by skeletal data represents age-specific mortality rates of the constituent age cohorts;
(ii) the raw proportion (3.5%) of skeletons under age one constitutes an underrepresentation. Two alternative adjustments were proposed: from 3.5 to 15.3% and from 3.5 to 29.7%;
(iii) a proportion $q = 0.488$ of births are female;
(iv) each child is born when the mother is 25 years of age;
(v) it is reasonable to base the level of the total fertility of a Maori woman over her reproductive life on conclusions reached earlier by Phillipps [4].

Assumption (i) was made for convenience of calculation. Citing Sattenspiel and Harpending [15] and Buikstra et al. [16], Brewis et al. argued that (i) is an approximation because "distributions of age at death generated by osteological analysis are not necessarily representative of age-specific mortality rates of the constituent age cohorts". See also Sutton and Molloy [17].

However, the mode of sampling entailed in obtaining the New Zealand prehistoric skeletal population involves skeletons from a period of some centuries. Other things being equal, there should be very little, if any, bias in the use of (i) in the present context. This will be treated in detail in a forthcoming study.

In respect of assumption (ii), Brewis et al. note that the 3.5% infant mortality indicated by the skeleton population appears unrealistically low. Weiss [18] states that the healthiest and most successful prehistoric and small-scale populations still had an infant mortality rate of about 10%. At the other extreme Maori infant mortality following the advent of infectious diseases with European colonization has been estimated to have been 36.5–41.9% (Pool [14]), which it is claimed may suggest a maximum infant mortality of about 30% in prehistoric New Zealand (see Brewis [19]).

A recent study by Navara [20] and the references therein support the choice $q = 0.488$ in assumption (iii) as being accurate.

Assumption (iv) is biologically unrealistic and was made for simplicity of calculation. In view of the highly non-linear way in which population growth rate depends on age-specific fertility we can expect this assumption to introduce bias.

We now turn to assumption (v). Phillipps states that Maori women gave birth at a fairly uniform rate from age 20 to age 34 (and then reached menopause), with an average of 3.4 children when they lived that period out fully. See also Sutton [5] for a discussion of her results. Her conclusion derives from estimates of the number of children produced by each of a sample of 33 women (estimated from two sites of pelvic pitting), coupled with corresponding estimates for age at death. The two pelvic counts were close in all but one of the skeletons (which we have set aside). In Table 14.1 we present a summary of data for the average numbers of children produced by the women concerned. We group the data into 5-year intervals.

The successive age groups of women have successively higher average birth counts. This makes a prima facie case against Phillipps conclusion that the childbearing years end in the mid-30s. The table further indicates age-specific fertility was highest in the late 20s and early 30s (one child per 5-year interval), with reduced fertility (0.5 children per interval) reaching down to the late teens (the three women in the age interval 20–24 all died at age 20 or 21) but also extending well into the 40s for women who lived that long. As with assumption (iv), we can expect assumption (v) to introduce bias into the results. In particular, childbearing does not occur uniformly over the childbearing years.

Table 14.1 Average number of births by final age cohort of mother

Age at death	No. of women	Average births
20–24	3	0.5
25–29	4	1.5
30–34	4	2.5
35–39	10	3.1
40–44	3	3.5
45–50	8	4.06

14.4 Refined Estimation

The use of life tables involves the determination of an appreciable number of parameters, which is an inefficient use of small data sets such as those used by Brewis et al. and Phillipps – our present database. This is notably the case if the object is to determine the annual rate of change r of a population, as this is a second-order parameter that is found indirectly. One way to combat such a problem is to make use of prior information.

Let $S(x)$ denote the probability that a woman lives at least to age x years and $F(x)$ the mean number of children that she has had by such an age if she lives that long. The value of x need not be an integer. There is a considerable literature indicating that suitable functions involving only two (sometimes three) parameters can give good fits to empirical data for $S(x)$ (the survival function) and $F(x)$ (the cumulative fertility function).

Our approach utilizes such a pair of functions. This makes the use of information about the general form of S, F in human populations and entails estimation from the data of only five parameters. At the most basic level, our knowledge of the onset of menarche means that for practical purposes we can take $F(x) = 0$ for $x < 15$. This procedure has such further advantages as automatically smoothing data (which would otherwise usually need to be performed as a further step) and obviating issues of quadrature errors involved in discrete calculations with lifetime tables.

Since the parameters are in general correlated, there are in principle problems in determining standard errors that reflect their joint values. However, the theory of Fisher information supplies (for a given probability p of a woman surviving to age 15) a joint approximately bivariate normal distribution for the two parameters associated with S and a joint approximately trivariate normal distribution for the three parameters associated with F.

Because distinguishing gender from a skeleton is difficult when death occurs before age 15, the estimation of p is made from a pooled sample of males and females.

An integral formula of Lotka linking S, F, p and q may be used to estimate r. A standard error for the estimate is induced by the approximate bi- and trivariate normal distributions associated with S, F and estimated from those distributions using Monte Carlo methods.

Full details of the statistical analysis would be out of place in this book and are published separately (Pearce et al. [21]).

Table 14.2 shows a spectrum of estimates for the population growth rate r associated with a range of infant mortality rates. All figures are presented as percentages. We note that while our point estimates differ somewhat from those of Brewis et al., their estimates lie in the relevant 95% confidence intervals for r corresponding to the relevant infant mortality level. We have in fact confirmed their skeletal-based result of a decreasing population. Both our results, given in Table 14.2, and those of Brewis et al. challenge Anderson's late first settlement claim which depends on consistently high population growth rates for the 600-year period covered by the skeletal data. It is clear from Table 14.2 that there is a very low probability for even a modest positive population growth rate occurring. To obtain such a growth rate would further require an implausibly low level for infant mortality.

The point estimates in Table 14.2 belong to a larger possible range of decline rates corresponding to various levels of infant mortality. They can be thought of as representing eight options which create a context in which plausible bounds for a

Table 14.2 Estimates for the population growth rate *r*

Options	Infant mortality	Point estimate of *r*	Confidence interval	Estimate of Brewis et al.
1	3.5	–0.915	(–3.55, 0.87)	–0.414
2	12.2	–1.251	(–3.57, 0.58)	
3	14.0	–1.325	(–3.60, 0.20)	
4	15.3	–1.380	(–3.74, 0.20)	–1.52
5	17.4	–1.469	(–3.94, 0.17)	
6	19.8	–1.573	(–4.08, 0.09)	
7	24.9	–1.804	(–4.16, –0.20)	
8	29.7	–2.035	(–4.46, –0.41)	

likely average population decline rate for New Zealand in the Little Ice Age can be considered.

The severity of the Little Ice Age, as it was felt in New Zealand, is clear from the decline rates of Table 14.2. However, before we can propose likely population estimates for the pa areas, for the non-pa areas and for the total population of the North Island in 1445, we need to consider with some care the possibility that differential rates of population decline may have applied in different parts of New Zealand in the Little Ice Age. That is, we need to consider the possibility that the population decline rates of Table 14.2 may not have applied fully to all areas of New Zealand in the Little Ice Age. That a significant differential did exist is clear: without it, the outcome for the whole population of the North Island would have been extinction.

14.5 Differential Rates of Population Decline

With permission from the New Zealand Archaeological Association, we have reproduced Tony Walton's map [22] showing the distribution of pa in the sample of the 931 pa that he studied (Fig. 14.1).

We have added two lines to Walton's map: one marking the southern boundary for a present-day mean annual temperature from 12.5°C to 15+°C (A), the other defining the southern boundary for a present-day 9°C July average monthly temperature (B). The correlation between pa density and distribution in Walton's sample and the regions defined by these modern temperature patterns suggests that, in the Little Ice Age, conditions for successfully growing tropical cultivars in New Zealand were mostly determined by temperature, with temperature itself largely determined by latitude. Grant suggests (see Fig 12.1) that in New Zealand the mean annual temperature had fallen from about 13.5°C in AD 200 to 11.9°C in the Little Ice Age. This drop in temperature seems to have led to a new delineation of feasible growing areas for tropical cultivars in the Little Ice Age, probably leading to the abandonment of some areas where they had been successfully grown in the warmer Medieval Climatic Optimum. The strong coastal distribution of pa in Tony Walton's

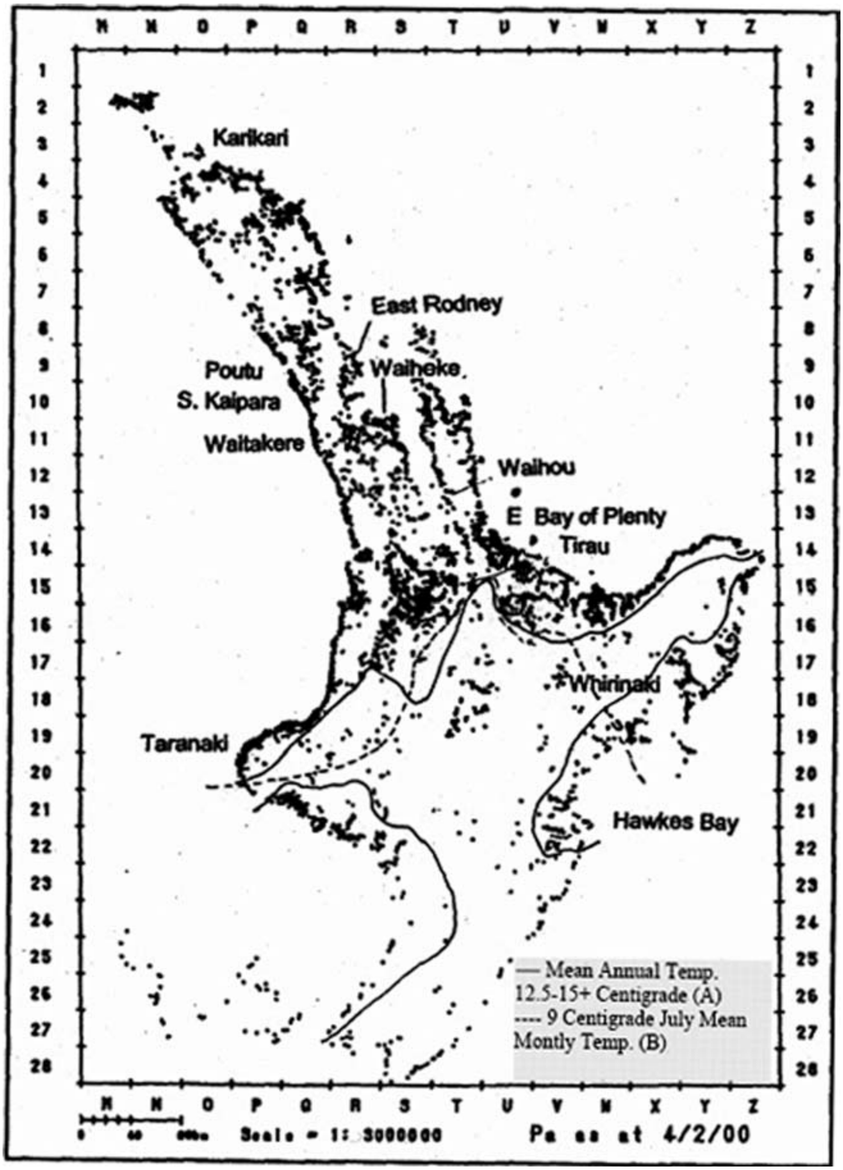

Fig. 14.1 Walton's map of pa distribution for a sample of 931 pa

map draws attention to the importance for survival in the Little Ice Age of a combination of the possession of horticultural land where tropical cultivars could be successfully grown with tribal access to marine, forest and estuarine resources.

That the importance of kumara harvests increased as forest, marine and estuarine resources dwindled is apparent from the scale of pa-building in the Little Ice Age to protect the horticultural areas of the northern part of the North Island and their stored harvests. Higher sea surface temperatures, especially on the northwest coast of the North Island lapped by the warm East Australian Current, may have partly reduced the loss of marine biota, but even in the north of the North Island loss of biota seems to have been extreme. Ironically, part of this loss appears to have been associated with deforestation in order to clear land for horticulture. Visser, for example, claims that the deforestation associated with the introduction of horticulture in the north of the North Island coincides with the disappearance of large fauna. He notes that the loss of large fauna was more severe in the north of the North Island than in the south of the South Island. In the north large land fauna disappeared after about AD 1300 and seals were rare by 1500. In the south of the South Island sea mammals may have been available until the 1800s [6].

Yet, with pa protecting the survival advantages of the north which were largely based on an ability to grow tropical cultivars, one would expect differential rates of survival between populations living in the major pa areas (recorded in Walton's map by pa distribution) and those living in other areas of New Zealand. The numbers and large population capacity of pa make the point that tribal survival was at stake and that in the north the protection of horticultural land and harvests was a priority.

In the south of the South Island which had small populations both in absolute numbers and in relation to resources, seal and marine populations appear to have survived possibly without major depletion. But although the settled hunter/gatherer populations of the South Island may have suffered lower decline rates than tribes in the southern part of the North Island, any southern amelioration of the overall population decline of New Zealand would have been small, given the smaller populations of the South Island. By contrast in the southern part of the North Island, with high populations by the beginning of the Little Ice Age, significantly lower temperatures than the north of the North Island and deteriorating resources, population decline rates in the Little Ice Age may have been extreme. It is not unreasonable to suggest that population decline rates in the south of the North Island may have been very much more than those of Maori in the major pa areas to the north. The global context for the Little Ice Age, discussed in Chapter 12, can be invoked here: there is evidence to suggest that in some countries there was just such a differential in population decline rates between richer and poorer areas.

It seems likely that since the time of Rakaihautu (about AD 840 by our calculations) the north of the North Island may have been the most densely populated part of New Zealand. It would always have possessed the highest average mean temperatures in New Zealand, the advantage of good soils and good access to forest, estuarine and marine resources. In the Medieval Climatic Optimum and, still more relevantly, in the Little Ice Age, because of higher temperatures (due both to latitude and perhaps to the flow of the warm East Australian Current along the west coast of the North Island) it possessed the best land for growing the tropical cultivars that became a key to survival in the Little Ice Age.

A positive consequence of there being a long-established high population density in the north of the North Island is that in the Little Ice Age a significant proportion of New Zealand's population would have lived in conditions which optimized their chances of survival. Populations in the major pa areas of the north would have been to some extent at least protected from the pressures towards population extinction that are all too obvious from the evidence for environmental deterioration during the Little Ice Age from midden analysis in all areas in the North Island and from evidence of severe population decline implicit in the skeletal data.

It is likely, then, that the pressures towards extinction in New Zealand were most felt in the south of the North Island. High populations, lower temperatures and correspondingly lower chances of successfully adapting tropical horticulture to provide insurance against starvation, declining marine, forest and estuarine resources (due both to the cold of the Little Ice Age and to erosion and environmental deterioration caused by slash-and-burn clearance of forest areas for horticulture) would have contributed to persistently unfavourable conditions in the south of the North Island. Significant population decline during the Little Ice Age would have been an inevitable consequence and demographic recovery unlikely.

Environmental evidence that is specifically related to sites which contributed to the skeletal evidence used by Brewis et al. records significant environmental deterioration during the Little Ice Age. The Wairarapa collection of skeletal remains, for example, was recovered from three sites in Palliser Bay on the south coast of the North Island. The Washpool Midden site contained five burials and other fragmentary material dated to the 12th century AD. Remains of two individuals were recovered from a second site contemporaneous with the Washpool Midden. A third site 2 km inland from the Washpool Midden contained remains of five individuals dated to AD 1480 ±70.

Douglas Sutton [23] in a study of these sites notes

> the increase in morbidity between the Washpool material and the cleft sample, that is between the 12th and 15th Centuries AD. This is most clearly reflected in the evidence of childhood illness which is virtually absent in the earlier people but universal in the later situation. This marked contrast corresponds with a broad-scale environmental deterioration.

Sutton points to the large numbers of labrid fish which are present in the early but not in the later sites, to the presence of "fern-root planes" in the teeth of the individuals at Washpool, suggesting unreliable kumara harvests, and to the contribution of slash-and-burn horticulture to environmental deterioration through reduction "in forest cover and increased sediment load in streams, which in turn affected coastal ecology and the quality and quantity of marine resources" (p. 65).

Edward Visser [24] who studied regional variation in fertility notes, in connection with Palliser Bay sites, that by AD 1350 the number of fish species caught had declined by 50% and that by AD 1540 fish presence in middens "was minimal". Though birds from 43 species are earlier represented in middens, by AD 1350 "the numbers of birds caught were so small as to be inconsequential in the diet" (p. 66).

Deterioration in biota in the Little Ice Age is recorded New Zealand-wide, though the south of the South Island may have been least affected. In the North Island, as we have seen, seal populations were depleted markedly by 1500, larger fish species in middens declined and the changing availability of shellfish is evident.

Isolated from a global context, the parameters for population decline provided in Table 14.2 may seem too extreme to be believable. The global context, however, shows the derived rates to be far from anomalous. The death of one-third of the population in the upland parishes of Scotland in the 1690s – a decline rate of 3.3% p.a. – twice that of Option 6 and higher than any rate in Table 14.2, links poor growing land with starvation and population decline. For England during the Little Ice Age, Lamb offers a clear example of differential rates of population decline The data he quotes for Oxfordshire, Northamptonshire and Norfolk from AD 1280 to AD 1350 [25], for example, records differential rates for population decline in these counties in the first 70 years of the Little Ice Age. (The Little Ice Age had an earlier onset in the northern than in the southern hemisphere.) The decline rate in those 70 years for the population of Northamptonshire and Oxfordshire villages was 1.5% per annum. But the rate of decline for Norfolk villages in the same period at 3% p.a. was twice that of villages in Oxfordshire and Northamptonshire.

A context of climate-driven demography enables us to predict that populations in poorer areas, with lower ceilings of population sustainability, and with high populations in relation to resources, will suffer greater decline. From the case for Norfolk we can argue analogously for a differential rate of population decline between richer and poorer areas in New Zealand and specifically between horticultural areas defended by pa and less rich horticultural areas or non-horticultural areas where pa density was low or pa were absent. In New Zealand the higher temperatures of the north would have been largely responsible for a differential in the Little Ice Age, for they determined the areas of New Zealand where tropical cultivars could be successfully grown. Yet, although in the north horticulture clearly offered the best chance for survival, this was only the case if horticultural land and its harvests could be defended. The extraordinary scale of pa-building, which we shall argue mostly took place in the first two generations of the Little Ice Age, can be seen as an inevitable consequence of the struggle for survival implicit in the skeletal data, in the evidence for environmental deterioration from midden analysis, and in the drastic lowering of ceilings of sustainability implicit in the record of species extinctions listed above and in Chapter 12. The comparison between the fates of human populations in Iceland and Greenland, the first surviving, the second becoming extinct, suggests that populations in some of the non-horticultural areas of the North Island in the Little Ice Age may have suffered a fate akin to the Greenlanders.

The rate of population decline in any one area would have depended directly on how high its resource ceiling was and how high its population was in relation to that ceiling. While it is claimed that moderate chronic malnutrition results in only a small decrease in female fertility, it is known than famine and starvation impact directly on female fertility and on infant survival (see Bongaarts [26] and Spielmann [27]). Conflict over land and resources in conditions of threatening or actual starvation would, moreover, have impacted on male mortality through warfare. Populations in areas with lower resource ceilings would have succumbed to starvation and population loss first and more drastically than those in better resourced areas.

Patrick Grant's analysis of the effects of the "warm wet erosion periods" that took place during the Medieval Climate Optimum, and of the two brief erosion periods that occurred during the Little Ice Age, helps to explain the long period over which, the skeletal evidence implies, population decline may have occurred in New Zealand. Grant's study of the effects of adverse climate on New Zealand's landscape and ecology shows that considerable fluctuations occurred in the severity of both the extreme warmth and extreme cold that mark the Medieval Climatic Optimum and the Little Ice Age in New Zealand. But both singly and cumulatively through their juxtaposition, severe conditions during these two climate periods in different ways had devastating effects on the ecology of New Zealand and on humans and other species included in that ecology. In the Medieval Climatic Optimum, as we have seen, the damage to the ecology was from erosion and gales which destroyed forests, coasts and estuaries and clogged rivers and lakes and from forest destruction associated with the introduction of horticulture. In the Little Ice Age there was a more direct reduction of biota at all levels through extreme cold. Populations which had already reached the limit of available resources in their tribal areas, by the beginning of or during the Medieval Climatic Optimum, would have been faced with starvation when the biota was reduced either by erosion or cold.

Given that much of the skeletal material that Brewis, Molloy and Sutton used in their analysis may have originated outside the best resourced, most densely populated pa areas, such as Taranaki, the Auckland Isthmus, the Bay of Plenty, the Bay of Islands and the west coast of the north of the North Island, it is possible that the long period of population decline established from the skeletal analysis may fully apply only outside the better resourced pa areas. It is likely that in areas with lower resource ceilings, and most especially the south of the North island, our recalculated parameters for the skeletal data accurately chart the scale of this decline. But in the areas with the best natural resources, especially after the successful introduction of horticulture, populations helped by the favourable warmth of the Medieval Climatic Optimum may have been better protected from starvation. The successful introduction of horticulture in favoured areas (and in the Medieval Climatic Optimum these may have included the south of the North Island) may have buffered inhabitants from a resource crisis that might otherwise have occurred in the Medieval Climatic Optimum following ecological damage to the biota.

In the Little Ice Age, as we argued in Chapter 12, the situation would, however, have been very different even in the north of the North Island. Cold would have reduced kumara harvests drastically. In the warm conditions of the Medieval Climatic Optimum, the tropical cultivars introduced into New Zealand would not have become cold-adapted. A simultaneous reduction in horticultural harvests and in the areas where they could be successfully grown, reductions in forest biota, shellfish and fish stocks, following on the heels of earlier reductions of biota during the Warm Waihirere erosion period, we have suggested, may have brought starvation to these richer areas for the first time. Even more obviously they may have brought starvation to areas where in the Little Ice Age tropical cultivars could no longer be grown. In the south of the North Island especially there may have been large populations which had been supported by horticulture in the Medieval

Climatic Optimum. It seems reasonable to suggest that the populations in the pa areas may have peaked after the establishment of horticulture, and that they may have been sustained, without significant loss, until the cold of the Little Ice Age descended. The wide range of dating for the skeletal material studied by Brewis et al. suggests, however, that some populations outside the warmer richly resourced areas may have faced starvation during the Medieval Climatic Optimum.

To summarize: that population decline occurred in New Zealand over 600 years, in some areas at least, is not in doubt. The global context establishes the likelihood, the skeletal evidence, and the demographic parameters derived from it establish there was severe population decline over centuries. In all likelihood the poorest areas with the highest populations in relation to resources exhibited the fullest decline. Pa defending horticultural land and its harvests imply starvation and conflict over land and resources. That there was population decline in pa areas is not in question, but the severity and extent of that decline is unclear and the differential rates of decline between richer and poorer areas need to be defined. Clearly there were modifying factors in the major pa areas. Applying the parameters derived from our skeletal analysis to the whole of New Zealand for 600 years would lead to population extinction and would imply impossibly high population levels at the beginning of the Little Ice Age.

One factor making for survival in the pa areas was so dominant that we suggest that it underpinned a completely different demographic regime in those areas. This was the cultivation of kumara. It provided two survival advantages. As we have repeatedly noted, defended stored kumara harvests provided some insurance against starvation. But after the medieval introduction of horticulture, harvested kumara would also have provided a weaning food for infants. Previously because of the dearth of soft foods, infants would perhaps not have been fully weaned until they were three or four. Access to kumara may have enabled breast-feeding in the pa areas to be reduced to two years. This would have given a major boost to female fertility by reducing the period of postpartum amenorrhoea and so reducing the spacing of children [6]. Potentially this could have doubled female fertility. Though the skeletal data suggests a maximum of five children for a woman, Maori tradition gives examples of rather larger numbers of children for some high-ranking and therefore better nourished women from pa areas in Little Ice Age New Zealand. Nuakaiwhakahua of Ngāti Ruanui from the major pa area of Taranaki, for example, is recorded as having nine children [28].

It can sensibly be argued that the demographic patterns revealed in Table 14.2 cannot have fully applied to the major pa areas and that a completely different demographic regime must have operated there. But in speaking of richer and poorer areas in New Zealand, it should be stressed, we are thinking of a spectrum of survival possibilities for both richer and poorer areas. A range of survival outcomes applies to each side of the pa/horticultural non-pa/non-horticultural division. Any population estimates applying to either side of the division represents an average of variable survival outcomes. These outcomes depend on at least three things:

(i) First, the survival outcomes for all tribal areas, whether occupying richer or poorer lands, would have depended on the local ceiling of sustainability in relation to tribal population levels.
(ii) Second, conquest or defeat in tribal conflict both between and within each division would also have determined relative survival outcomes for different tribes. The building of nearly 7,000 pa shows the importance for the horticulturalist of not suffering defeat either at the hands of other tribes from pa areas or at the hands of outside tribes attempting to gain a horticultural foothold.
(iii) Third, decade by decade, improvement or worsening in the impact of climatic stress on the biota and on horticultural harvests would have affected survival outcomes. Although, working with limited data, we can only consider average rates of decline, it seems likely that there were constantly fluctuating population decline rates over the 600-year period represented by the skeletons studied.

14.6 Establishing Estimates for the Total Non-pa Population of the North Island in AD 1445

Given the extreme demographic implications of the population decline rates derived from skeletal evidence and recorded in Table 14.2, we can reasonably argue that the most plausible overall decline rate for the non-pa areas of the North Island will be one that minimizes estimates for population levels in 1445 and is correspondingly based on a conservative rate for infant mortality. Option 8, the last estimate in Table 14.2, with the highest infant mortality rate at 29.7% and the extreme population decline rate of 2.035% p.a., for example, implies impossibly high population levels for the non-pa areas of the North Island in 1445: a population estimate of 500 times the population in 1801. Even Option 5 implies a population for the non-pa areas alone 194 times the population in 1801. Option 1, at the other end of the spectrum, which implies the lowest population estimates, has to be discounted at the outset because its estimate for infant mortality at only 3.5% is unrealistically low in the light of Weiss's claim that prehistoric populations in the best of circumstances had an infant mortality rate of 10%. Option 2 has a feasible infant mortality rate of 12.2% and implies less extreme population levels: the population in 1801 would be 1.13% of that in 1445. As the most conservative of the remaining options, it is a plausible first choice.

To use the population decline rate of Option 2 to obtain an estimate for the non-pa population of the North Island in 1445 requires us to make one assumption, an assumption as to the number of survivors in 1801. If, with a decline rate of 1.251% p.a. from Option 2, maintained over the 356-year span from 1445 to 1801, we assume the survivors in the non-pa areas numbered 10,000 in 1801, we can derive an estimate for the total non-pa population in the North Island in 1445 of 884,000. Estimating there to have been 6,000 survivors in 1801 would give a total non-pa population for the North Island in 1445 of 530,000. In either case the remnant population is only 1.13% of the 1445 population. The threat of extinction faced by Maori in the non-pa areas with the full force of even the lowest feasible population decline rate listed in Table 14.2 is undeniable.

Calculations using options from Table 14.2 with higher population decline rates than Option 2 will have correspondingly higher population estimates for the total population of the North Island non-pa areas in 1445, ranging as we have noted as implausibly high as 15 million for Option 8.

Table 14.2, then, records a range of population decline rates in Little Ice Age New Zealand, linked to infant mortality rates. So extreme are most of these population decline rates that they point unambiguously to the conclusion that a 12th or 13th century first settlement for New Zealand would have been out of the question. In the demographic context revealed in Table 14.2, an argument for the continuous high population growth levels required for a late first settlement of New Zealand cannot be sustained.

14.7 Evidence from Field Archaeology

In Section 14.5 we suggested estimates for the total North Island populations living outside the major pa areas of the North Island in 1445. These estimates were tied to assumptions as to the number of survivors from these populations in 1801. In this section we estimate the total pa population in the North Island in 1445. This estimate depends on evidence from field archaeology. We can only propose a differential rate of population decline in the pa areas as opposed to the non-pa areas once we have estimates for the total pa population in the North Island.

Not many attempts have been made to estimate the total population of pa from field evidence. In 1983, Aileen Fox [29] derived a formula that one household of six, without children, equals one *whare* (hut) plus two kumara pits on one terrace. Counting terraces and pits she arrived at population estimates for perhaps a dozen pa [30]. Her attempt was made with the standard assumption of rising populations. She therefore saw the estimates she derived using her formula as maximum estimates. In the context of falling populations, however, these become minimum estimates.

There are inherent problems with Fox's approach: the size of terraces varies considerably from pa to pa and even within a pa. A terrace 10 m by 5 m and one 30 m by 20 m might be adjacent. Faced with the Otatara pa (see Fig 13.2) which has so many small terraces they number thousands, Fox perhaps remembering Best's comment that the "multitudinous linchets [small terraces] hewn out of the slopes would accommodate thousands of people" [31] referred to them as a "multitude" [32] and evaded the demographic implications of applying her formula to them. Kumara pits likewise vary greatly in size and capacity.

Recent painstaking assembly and analysis of pa data by Tony Walton and Nicola Molloy for the New Zealand Archaeological Association (2006, personal communication), makes the task of demographic analysis from pa data more feasible than when Fox attempted the task. The data assembled by Walton and Molloy lists the area of 931 pa (a significant 13.8% sample of the 6,956 pa listed in the New Zealand Archaeological Association's national site register). Adding the total area for these 931 pa gives an overall total area of almost 4 million m^2 (3,930,000). Multiplying this number by 6,956/931 gives an estimate for the total area of the 6,956 listed pa of almost 30 million m^2 (29,361,000). Simple arithmetic enables this estimate for the total area of New Zealand pa to become the basis for a population estimate for the major pa areas.

A conservative approach seems appropriate. The first step in such an analysis is to deal with the issue of double-counting. Large and very large pa seem to have had a significant role in regional defence, acting as citadels providing defence, especially against outside attack, not only for local undefended settlements but also probably for the inhabitants of smaller more vulnerable local pa. From Walton's data it is clear that 50% of pa were small with areas of less than 2,100 m^2. To avoid double-counting the populations of these smaller pa we suggest discounting the population capacity of all pa less than 2,100 m^2 in area: that is, we suggest discounting the area of 50% of all listed pa at the outset. If we discount all small pa, the total area of the remaining pa reduces from 29,361,000 to 25,660,000 m^2 (a reduction in area of only 12.6%). As we are hoping to establish the population capacity of pa in 1445, discounting all small pa will also avoid problems arising from the possibility that many small pa may have been built after 1445 to meet the needs of small groups.

Second, while the building of small pa may have been spread over time, in the context of rapidly falling populations, we have suggested that it is likely that most large pa would have been built in the first two generations of the Little Ice Age (AD 1400–1445) when there were large populations to build pa and to defend them. In Chapter 15 we suggest there has been a confusion in dating some pa where different stages in a sequence of fortifications have been confused with initial construction. We note that consecutive disturbances of stratigraphy through a series of sequential fortifications will have confused dating estimates.

Initially pa may have relied for their defence mostly on the natural defensibility of the site, with minimal fortifications, perhaps only a scarp and a palisade or a ditch and palisade, and on having large numbers of warriors to defend them. We suggest that the sequence of later fortifications adopted for a pa was tied to its "half-life", that is, tied to each of the stages when, given drastically falling populations, the numbers of warriors able to defend a pa had fallen to half the number it had at the beginning of that stage. At the end of this section, we estimate the half-life of a pa in the Little Ice Age to have been 107.1 years (with 10,000 survivors from the non-pa areas in 1801) to 108.3 years (with 6,000 survivors). This suggests a triple sequence of fortifications during the Little Ice Age. This is discussed more fully in Chapter 15.

In determining the total population capacity of pa in 1445 we have limited consideration to the 90% of large and very large pa that we deem to have been built by 1445, that is we have limited consideration to 90% of pa which have an area greater than or equal to 2,100 m^2. Ninety per cent of 25,660,000 m^2 gives an area of 23,094,000 m^2.

Table 14.3 Data comparing living area to total area of pa

Living area	Total area	Living area	Total area
360	445	700	800
1,667	1,780	5,932	7,860
545	750	2,500	3,900
2,135	2,318	750	1,490
383	500	1,875	4,775
1,463	1,628	550	660
915	1,400	924	1,114
2,469	3,121	1,470	2,510
2,255	2,530	800	1,120
4,756	5,819	725	2,420
5450	10,300	575	1205
2,133	2,770	3,835	4,430
2,460	3,045	815	1,300
2,200	2,325	1,090	1,800
1,582	2,032	2,516	5,670
4,720	6,500	645	1,800
675	715	677	1,810
1,195	1,900	140	150
6,150	6,900	1,274	1,365

Third, to obtain population estimates from pa data, we need to consider the proportion of living area to total area for pa. As can be seen from Table 14.3, the data is limited.

Table 14.3 presents a list of the 38 pa, drawn from Walton's sample of 931 pa, for which information about both defended living space (y_i) and total area (x_i) are provided. A basic model to link these is $y \sim a + bx$. A regression indicated that the constant a was largely irrelevant, and that the correlation between x and y was 0.9281. The variation inflation factor was 1, so there was no evidence of multicollinearity. The Cameron and Trivedi decomposition of the IM test and the Breusch–Pagan/Cook–Weisburg test both indicated heteroscedasticity. Working with robust standard errors gave $y_i \sim b\ x_i$ for coefficient $b = 0.676$, with robust standard error 0.049 for the coefficient b. Thus a 95% confidence interval for b is (0.576, 0.775).

The proportion of defended living space to total pa area can thus be estimated as $0.676 \times$ total area, with 95% confidence interval (0.576, 0.775) for the multiplier.

If the total area of 90% of all pa of 2,100 m^2 or more is 23,094,000 m^2, their total defended living space in 1445 will be 15,607,000 m^2.

Raoul Naroll [33] has suggested "that the population of a prehistoric settlement can be roughly estimated by archaeologists as of the order of one-tenth of the floor area in square metres occupied by its dwellings". Naroll's estimate of 10 m^2 per person would make our 1445 double-count-corrected estimate for the total defended living area of pa in 1445 of 15,607,000 correspond to a total pa population in 1445 of 1,561,000.

For this population to reduce to 156,000 in 1801 (adopting Rutherford's higher estimate for the total population in the North Island of 166,000 and assuming that there were 10,000 survivors in the non-pa areas) gives a decline rate of 0.645% per annum. This is 51.7% of the most probable decline rate based on skeletal evidence for the non-pa areas (1.251% per annum of Option 2).

As we have seen, if there were 10,000 survivors from the non-pa areas in the North Island in 1801 and the decline rate from Option 2 were fully applied, this would correspond to a total non-pa population in 1445 of 884,000. Combining pa and non-pa populations would give an estimate for the total population of the North Island in 1445 of 2,444,000. Though the non-pa population would have represented 36.15% of the total North Island population in 1445, by 1801 it would represent only 6.0%. If the non-pa population was only 6,000 in 1801, then the pa population would have decreased at an average rate of 0.6377% per annum which is 50.9% of the Option 2 skeletal decline rate of 1.251% per annum. Both estimates for the differential rate of population decline in the pa areas as opposed to the non-pa areas of the North Island are comparable with the 50% differential decline rate Lamb records for Little Ice Age England between Oxfordshire and Northamptonshire and the more populous Norfolk. With 6,000 survivors from the non-pa areas in 1801, the population estimate for the non-pa areas in 1445 would be 530,000. The total population of the North Island in this case would be 2,091,000. Though in 1445 this non-pa population would have been 25.4% of the total North Island population, by 1801 the remnant non-pa population would represent only 3.6% of the total North Island population, a figure close to extinction.

The same results lead to a calculation for the "half-life" of a pa of 107.1 years where there are 10,000 survivors from the non-pa areas in 1801 and of 108.3 years where there are 6,000 survivors. This is discussed further in Chapter 15. The half-life is higher for smaller numbers of survivors, but is bounded above by 110.1 years for Rutherford's total North Island estimate of 166,000 in 1801.

14.8 A Summary

With a total defended living area for 90% of large pa of over 15 million m^2, the obvious question arises, in the light of discussion in Chapter 11, as to why pa with such a population capacity would have been built to serve a supposedly maximum prehistoric population in 1801 of less than 200,000. The suggestion of abandonment because of *tapu* (taboo) cannot explain such an extraordinary discrepancy, especially when, as Fox claims, "Excavation and radiocarbon dating have shown that most pa have a history of occupation covering several hundred years, which included successive alteration of the defences" [34].

In a global climate context, the answer to such a discrepancy between pa capacity and pa populations in 1801 is obvious: the demographic pattern is the reverse of the one generally accepted. The population at the end of the 18th century is a minimum, not a maximum population for the period from 1400. The majority of pa were built, occupied and defended in the early 1400s, not in the period leading up to Cook's arrival.

Of importance for the central thrust of the book, the range of severe population decline rates derived from skeletal evidence and presented in Table 14.2 makes it very clear that the steadily rising population growth rates proposed by late settlement theorists are inconceivable for Little Ice Age New Zealand and, given the latitude of New Zealand, inconceivable in a Little Ice Age global context.

Extreme population losses in New Zealand in the Little Ice Age imply a long demographic history for Maori in New Zealand generating high populations outstripping resources and engaged in intense conflict over land and resources in the Little Ice Age. Late settlement of New Zealand requires evidence for continuous high population growth rates. High population growth rates are incompatible both with the skeletal evidence we have considered in this chapter and with the evidence for severe environmental deterioration in Little Ice Age New Zealand considered in this chapter and in Chapter 12. The most obvious interpretation of the high population decline rates implicit in the skeletal data is that they reflect severe population losses resulting when high populations at the beginning of the Little Ice Age confronted drastically lowered ceilings of sustainability. The population capacity of large and very large pa, established from Walton's research, supports the inescapable conclusion that there were large populations in New Zealand at the beginning of the Little Ice Age and that these populations were the result, not of medieval migrations only 120 years before, but of a long demographic history and of a very early first settlement.

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Chapter 15
Dating the First Settlement of New Zealand: A Power Law Analysis

Abstract Chapter 15 uses a powerful new approach for dating the first settlement of New Zealand – an approach based on power laws associated with the rank size distribution of New Zealand pa (hill-forts). Because the pattern of pa settlement has grown out of ancient settlement patterns, pa rank size distribution retains an imprint of the prior history of settlement in New Zealand. Thus it is possible through mathematical analysis of pa rank size distribution to estimate a population growth rate for New Zealand averaged over the full period of its settlement and so to calculate the most likely date for first settlement from the appropriateness of population growth rates associated with specific possible settlement dates. The size of a founder population can also be estimated directly from a rank size distribution. Retrieving such information from New Zealand's past has been made possible by the recent compilation of a significant sample of the areas of 931 pa and recent publication of Walton's rank size distribution curves. The population growth rates estimated using this power law approach show that the first settlement of New Zealand occurred early in the Lapita migration period (3,600–3,000 years ago). The chapter concludes with a summary of the demographic evidence presented in Part II and with discussion of its human implications.

Keywords New Zealand pa · Rank size distribution · Founder population · Early growth rate · Fortification sequence

15.1 Pa Rank Size Distribution

Extreme population losses in Little Ice Age New Zealand are implicit in the skeletal analysis of the last chapter. The scale of the losses can be readily seen through comparison of estimates for the total population of the North Island in 1445 (2,113,000–2,473,000) and in 1801 (155,000–175,000). They can also be envisaged by considering the correlation between pa population and pa capacity in 1445 (with an area per person of 10 m^2) and their disparity in 1801 (with an area per person of 92.35 m^2–107.63 m^2). Large populations in 1445, we have argued, imply a long demographic history for Maori in New Zealand. Establishing the time depth of this

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history, in particular estimating the date for the first colonization of New Zealand, is our task in this chapter.

For this task we have chosen a new approach to New Zealand palaeodemography, an approach that involves minimal assumptions. Not only is it therefore robust but, as we shall show, it has unusual potential for illuminating the early demographic history of New Zealand. It involves a power law analysis based on the rank size distribution of New Zealand pa.

In 2006 Tony Walton published rank size distribution curves for pa of all sizes in a sample of 931 pa [1]. Walton commented on the pa rank distribution he obtained:

> The distribution has a long upper-end tail. There is a small blip in the curve around 9000 m^2 (which could be a sampling error). Above about 10,000 m^2 (1 ha) there are 60 sites (representing 6–7% of the total) of various sizes up to 18 ha.

> A rank size distribution is used to show the relationship between pa size and rank. What is important is any significant change in slope. Fig. 8 shows a change of slope at both ends of the distribution and this may indicate a specialised role for the very large and the very small sizes. The change at the upper end of the distribution is at around 10,000 m^2 (1 ha). This is also a feature of other data sets such as the Western Bay of Plenty (Fig. 9) showing that it is not just a peculiarity of the combined sample. If just the sites above 1 ha in size are displayed, a similar pattern is evident (Fig. 10) in the upper-range tail, with a change of slope at above 3.2 ha. (These figures show lower-tail and upper-tail power-law behaviour – but it is not clear what this means.)

Walton then posed a number of questions:

> The usual explanation for very large pa is that they are part of a wider regional system of defence. They provided a place for people from across a region to gather in numbers to protect themselves when threatened by large-scale incursions. Is this an explanation for the 6–7% of pa on the slope at the upper end of the rank-size distribution? Does this suggest that large extra-regional threats and incursions were a common occurrence in prehistoric times? Were the large-scale raids across large parts of the country in the early 19th century a continuation of an older pattern? Or were all these large sites constructed in late prehistoric times or the early contact period?

In answer to Walton's last question, we argued in Chapter 14 that in a context of falling populations it is likely that most large and very large pa were constructed in the first two generations of the Little Ice Age, that is, roughly between 1400 and 1445, when there were large populations to build and defend them.

The answer to Walton's more basic question as to the meaning of "lower tail and upper-tail power law behaviour" is more complex. A comprehensive discussion of the relevant aspects of the rank power law is beyond the scope of the book. We offer a general explanation here as background to our attempt in the first instance to use power laws to estimate a population growth rate for New Zealand from first settlement to 1445.

The potential of a power law approach for casting new light on the early palaeodemography of New Zealand arises from the fact that power laws associated with pa rank size distribution not only reflect the immediate history of pa built in the Little Ice Age. Pa rank size distribution curves retain an imprint of the prior history of settlement in New Zealand. They do so because the pattern of pa settlement is not an isolated phenomenon but has grown out of ancient settlement patterns. Thus, as we shall show, it is possible, for example, through a mathematical analysis of Walton's data to estimate a population growth rate for New Zealand averaged over the full period of its settlement. Even the size of a founder population can be estimated directly from the pa rank size distribution curve.

Throughout New Zealand's history, the distribution of settlement sizes incorporated information about the original founder settlement and about the history of development from that settlement but the survival of that information was inhibited by the perishable nature of the materials used to build settlements. With the construction of enduring pa this information became manifest, became as it were frozen in earth and wood. In the case of New Zealand pa, this evidence once secured is effectively permanent. Despite the drastic population losses in the Little Ice Age and consequent later mismatches between pa capacity and population levels, the original population capacity of pa, represented by area alone, preserves evidence for earlier population levels and settlement patterns.

When pa are ranked in decreasing order by size, and area graphed against rank, the plot exhibits upper-tail power law behaviour. Similarly when pa are ranked in increasing order by size, and area graphed against rank, the lower tail exhibits a power law.

A parallel phenomenon has been known for half a century with cities and their populations. Indeed, the phenomenon is true from major cities to villages of only 30 inhabitants [2]. That a pa rank size distribution follows power laws is hardly surprising. If the pa area occupied per person and the proportion of pa area occupied by people both vary over modest ranges, then the distribution of pa sizes can be expected to reflect that of the sizes of human communities with only differences of scale. Community sizes may be described in "equivalent pa areas" and the pa size distribution serves as a proxy to the distribution of the sizes of the communities of their occupants.

After some early difficulties, fairly satisfactory explanations are now available for one and two tail rank-size laws for community sizes, although these involve some technical points of probability and statistics. See, for example, Gabaix (1999) [3], Reed and Hughes (2002) [4] and Reed and Jorgensen (2004) [5].

In the geometric Brownian motion model of Reed and Hughes an initial community grows in size and also produces daughter communities, which behave similarly. Under mild assumptions we have asymptotically a collection of communities: the size of a constituent community has (for appropriate positive constants $\alpha,\ \beta$) a double Pareto density function of the form

$$f(x) = \begin{cases} A(x/X_0)^{\beta} x^{-1} & \text{if } x \leq X_0, \\ A(X_0/x)^{\alpha} x^{-1} & \text{if } x > X_0 \end{cases}$$

which exhibits power law behaviour in both tails. The imprint of history is carried in particular by the parameter X_0 which is the size of the original community.

It is worth commenting at this point that because the distribution of pa rank size occurs asymptotically, it has no direct time frame. This can only be obtained archaeologically, that is, in New Zealand, by direct recourse to pa data. The power law analysis we undertake is thus necessarily based on the pa data for the sample of 931 pa recently prepared by Tony Walter and Nicola Molloy for the Archaeological Society of New Zealand. We use this data to effect a power law analysis of Walton's rank size distribution curves. This analysis gives us direct access to population growth rates from first settlement to AD 1445 via an estimate for the size of the founder population. This makes it possible to determine the most likely date for the first settlement of New Zealand.

Data supplied by Walton from the 931 pa database was fitted well by the double Pareto distribution and gave in particular a pa equivalent area of 4,281.85 m^2 for X_0 in the founder community. An estimate for the percentage of defended living area to total area, however, is needed before a founder population can be estimated. As we saw in Chapter 14, Table 14.3 provides a means of estimating defended living area from total pa area:

Living area = 0.676 × total area

with the 95% confidence interval (0.576, 0.775) for the multiplier.

Multiplying the estimate for the pa equivalent area of the founder community of 4,281.85 by 0.676, to give the dwelling area of the founding settlement, provides the result of 2,894 m^2.

Taking the defended living space for Maori pa as corresponding to Naroll's dwelling area, we can divide the dwelling area of the founder settlement by 10 m^2 to give an estimate for the founding population of 289. It must be stressed that the Naroll estimate of 10 m^2 is very rough. However, an estimate of 289 for the founding population is consistent with a founding population associated with a fleet of six or seven canoes carrying 40–50 people each. Although Flannery quotes 500 as the minimum isolated mammalian population needed to ensure survival [6], 289 might still be thought of as a significant population. That the first migration to New Zealand survived despite a probable near-extinction event in its early history (see Chapter 20) might be taken as evidence of the plausibility of the power law estimate for the founding population. The near-extinction event took place 17 generations after first settlement by which time, as we shall see, the population would have been of the order of 797 and so technically largely free from the danger of extinction.

15.2 Estimating the Date of First Settlement

The area derived from the Pareto distribution (4,281.85 m^2) is the area equivalent of the number of people in the founder population. This area equivalent can also be used for estimating the population growth between first settlement and 1445.

As will be obvious from Part I, dating for an early first settlement of New Zealand is subject to climate constraints. First settlement has to have occurred either before the global cold period began in about 1000 BC (a first-wave migration) or after 400 BC when long-distance voyaging again became possible (a second-wave migration).

In Chapter 14 we found after a double-counting correction a total pa area of 23,094,000 m^2. Dividing this by 4,231.85 (the area estimate for the founder settlement) gives 5,457, the factor by which the total pa area in 1445 has increased from the area of the founding settlement and so the factor by which the total pa population has increased from the founding population.

For an early first-wave settlement in 1500 BC close to the beginning of the Lapita migration period (3,600–3,000 BP) and fully occupied pa dating to 1445, this factor corresponds to an average growth rate of 0.293% p.a. This calculation has the advantage of being free of the uncertainties inherent in the use of Naroll's method.

We note that without the double-counting correction, the corresponding result is 0.300% per annum. The smallness of the discrepancy is not surprising. Removing all small pa only means removing 12.2% of the total area of all pa. And we note that all the pa extracted as a double-counting correction are all well below X_0 which is the mode of the double-tail distribution, so that the correction does not change the mode of the distribution. The structure of the distribution is only partly modified because the mode is intact and it is the mode that is relevant to the size of the founder population.

For a late first settlement in 1000 BC at the end of the Lapita migration period, the population growth rate to AD 1445 would be 0.353% per annum, a significantly higher rate and so inherently less likely for tribal people who for most of their existence in New Zealand were settled hunter/gatherers. This suggests the likelihood that the first settlement of New Zealand occurred closer to the beginning than the end of the Lapita period.

For a very early second-wave settlement in 400 BC our estimate is for an average population growth rate of 0.468% per annum. This high growth rate for a second-wave settlement immediately establishes it as implausible. It is improbable that such a high growth rate could be sustained for 1,844 years for a population that for nearly 1,500 years of that span led a settled hunter/gatherer existence. This result makes it immediately clear that the first settlement of New Zealand was a first-wave colonization. The calculations above, moreover, establish that the first settlement of New Zealand was most likely an early Lapita-age colonization, one that took place perhaps 200–400 years before the settlement of Western Polynesia and, given recent late datings for first settlements in Eastern Polynesia, perhaps as much as 1,900 years before Eastern Polynesia was settled. This perception represents a major change in the way in which the settlement sequence in the Pacific is viewed.

As noted in Chapter 14, a founding population of the order of 50 is often assumed by prehistorians, sometimes with the connotation of accidental colonization. This number has the disadvantage of being well below Flannery's viability level of 500 for a mammalian population [6]. Suppose we were to assume a founding population of only 50 in 1500 BC. Taken with the estimate of a pa population of 1,561,000 in 1445, this would give a completely unrealistic average population rate of increase of 1.00% p.a. as against the 0.29% p.a. for an initial population of 289 at the same date. Sustained for 2,700 years for a settled hunter/gatherer population, a growth rate of 1% p.a. is untenable. This gives support to our estimate of the size of the founding population. Further, a first-wave colonization around 1500 BC with a founding population of 289, presumably travelling in a fleet of canoes, would have been almost certainly deliberate.

More refined estimates made from analysis of traditional genealogies in Chapter 20 suggest a date for the first settlement of New Zealand around 1358 BC. Interestingly this date fits the peak in El Niño activity Anderson et al. chart in a recent paper as corresponding to likely “pulses” in the colonization of the Pacific [7]. In Chapter 20 we argue that a consilience of evidence – climatic, genealogical and demographic – also places first settlement early in the Lapita colonizing period. That a first settlement of New Zealand may have taken place so early is not surprising in the light of our central paradigm. Indeed it is perhaps to be expected given the large landmass and protein richness of New Zealand, which, especially as it was uninhabited, would have made it a prime migration target for first-wave colonists. A population growth rate from 1358 BC to AD 1445 of 0.307% per annum, appropriate to the hunter/gatherer existence of their descendants, supports this likelihood.

Because of inadequacies in data, we have not attempted to estimate South Island populations. We note, however, that if the South Island population in 1445 were 20% of the total North Island population (418,000–489,000), the average growth rate from a 1358 BC first settlement to 1445 for an increased total New Zealand population (2,509,000–2,933,000) would only be 0.324–0.330% per annum as opposed to 0.307% per annum. In this calculation we have kept to a founder population of 289. This corresponds to the mode of pa populations and seems likely to be close to the modal value of the distribution of sizes of all communities at the onset of the Little Ice Age.

Tom Dye and Eric Komori have written an interesting paper on Hawaiian palaeodemography using aggregate 14-C age determinations to establish population increase and decrease rates over time [8]. Frequency distributions of 14-C age determinations from an extant archaeological carbon deposit are interpreted as reflecting relative changes in population within a region over time. Two first settlement dates for Hawaii are considered, AD 1 and AD 400. For the period AD 1–1832 annual rates of increase vary from –2.53 to 2.75% (though these extreme dates are sustained only for a few decades and the dating of the period of high positive increase suggests it may represent the effects of Tahitian, Samoan and Marquesan migrations to Hawaii in the Medieval Climatic Optimum. There is an average 0.25% per annum over the entire period. With a first settlement date set at AD 400, the mean annual rate of increase is 0.32% with a range of –1.1 to 2.75% per annum.

However, Dye and Komori’s overall average includes a period of significant population decline of 2.535% per annum during the Little Ice Age. This estimate is higher than even the highest estimate (2.04% for Option 8 in Table 14.2) derived from the New Zealand skeletal data. But the overall population growth rate for Hawaii at 0.25% per annum is less than that of New Zealand, perhaps reflecting the long-term advantage New Zealand had over Hawaii in possessing the largest land mass in the Pacific, a land mass 15.6 times that of Hawaii. Internal migration within New Zealand may have provided an answer to resource shortages in particular areas for possibly 2,000 years.

The analysis of this section shows the usefulness of a power law approach for illuminating the early demographic history of New Zealand. The sizes of founder populations have in the past been guessed. Frequently this has also been the case for population growth rates. Though skeletal evidence has offered a means for estimating population growth rates, statistical problems in the past have hampered analysis. In this chapter and in the last we have been able to demonstrate the usefulness and consilience of several independent approaches for estimating population growth rates covering the time span in New Zealand from first settlement to the first decades of the Little Ice Age. Skeletal evidence, evidence from field archaeology and a power law analysis reveal similar demographic patterns and their demographic estimates are consistent with one another. Derived population growth rates using a power law approach show the implausibility of even a very early second-wave first settlement for New Zealand at the end of the global cold period in 400 BC. And a power law approach, which involves the minimum of demographic assumptions, supports a date for first settlement close to the beginning of the Lapita migration period (3,600–3,000 years ago). The consilience of demographic evidence obtained by independent methods provides robust support for the prediction inherent in our central paradigm of a first-wave Lapita-age first settlement of New Zealand.

15.3 An Explanation for the Fortification Sequence of Maori Pa

In the last section, as in Chapter 14, our focus has been on demographic analysis. We turn now to a consideration of the human consequences of the population losses that have been demonstrated through analysis. Skeletons record Harris lines in bones which indicate periods of starvation in childhood. They record "fern-root planes" in teeth which show a high dietary dependence on fern root which over time led to enamel loss, tooth infection, blood-poisoning and early death. High infant mortality, low life expectancy for children and adults and evidence of premature ageing all reflect the harsh conditions of the Little Ice Age and their impact on human life. The scale of pa-building and the population capacity of pa in the north of the North Island reflect the psychological and physical stress accompanying an ever-present risk of attack. The history of pa fortification, our focus in this section, shows such stress spanning centuries. The impact of continuing population losses is reflected in the history of pa defence itself.

In Chapter 14 we suggested a relationship between fast falling populations and the fortification sequence of pa. From average population decline rates for pa areas in the Little Ice Age, it is clear that the total pa population would have halved roughly every 107–108 years. We have termed this the "half-life" of a pa and suggest that successive fortifications were tied to this half-life, the point at which only half the warriors present at the beginning of each half-life were left to defend the pa. To abandon a large pa sited in an optimally defensible position because it had only half the number of warriors needed to defend it would rarely have been a good option. A better alternative would have been to add additional fortifications to make the pa defensible by half the number of warriors that would originally have protected it.

A modern analogy suggests itself: that of Gustav Erikson and his grain ships. These, the last great sailing ships, plied their way from South Australia to the Oland Islands of Finland in the 1930s, carrying South Australian wheat to Europe. With their moonrakers (topmost sails) reaching to the height of an 11 storey building, they sailed through the "screaming sixties" in the Great Southern Ocean, dodging icebergs, rounding Cape Horn and making their way north through the Atlantic at a time when sailing ships were already dinosaurs. Their life was extended by Gustav Erikson's invention of mechanical devices that enabled them to be crewed by as few as 50 men. It was the torpedoes of World War II that put an end to the last era of sail.

If the building of additional defences was tied to the successive half lives of pa, and, as we calculate, these half lives occurred every 107.7 years, you would expect to see the first and most major round of fortifications in about 1553. There does appear to be archaeological evidence that this was the case. Matthew Schmidt [9], following a protocol for chronometric hygiene, reduces 317 radiocarbon dates used to determine the beginning of the fortification period in Maori pa to an acceptable 60. He concludes:

> If we consider the number of calibrated dates that overlap at 1550 cal AD from the robust and maximum categories for both marine shell and charcoal, the different sample types indicate a commencement of fortification building by 1550 AD.

Where Schmidt speaks of "a commencement of fortification building" in AD 1550, we would suggest, rather, the building of a first round of additional defences. By our theory a first round of fortifications in 1553 would be followed by a second round of fortifications in 1660 and a third round in 1768, each of these periods corresponding to a halving of the number of warriors available to defend a pa. For the archaeologist, the disturbance of stratigraphy as each new round of fortifications was constructed would make the pursuit of chronometric hygiene difficult and confound dating.

We follow Nigel Prickett [10] in seeing pa as belonging to a defensive system in which the largest pa act as citadels and are supported by medium-sized and smaller pa which act as a chain of defence. In times of conflict all would act as refuges for related peoples living outside in small undefended settlements and smaller more vulnerable pa. In other words, we take the total pa populations to include the total population of a pa area, including those people usually living in undefended settlements. Nigel Prickett cites S. Percy Smith's wonderful example of the co-ordinated defence of a pa area [11]:

> Beyond the tactical support of adjacent paa is the general strategic advantage of a network of small fortifications. A network of paa allows independence, with mutual support in case of external threat. If the threat was sufficient the occupants of the fortified homesteads could withdraw to a nearby large fortification which might act as a tribal or sub-tribal 'citadel'. In the first decades of the last century a northern taua was defeated by a combined force of Nga Mahanga at the large paa, Ngaweka, at the forest edge on the south bank of Stoney River, by just such a strategy. . .On first hearing of the approach of a hostile force, the Ngamahanga hapu, of Taranaki, all assembled to consider what steps should be taken to meet it.
>
> Some proposed that each hapu should remain in its own pa and await attack, but one of the chiefs of Nga-weka arose and said, "Kia kotahi ano taringa hei ngaunga maa te hoa riri." ("Let there be only one ear for the enemy to bite.") (Smith 1910: 312).

15.4 Pa Defence with Falling Populations

The defence of a pa must always have been concentrated on the defence of its perimeter. The most naturally defensible sites, because they are situated on crags and cliffs or rivers, will have the best naturally protected perimeters and so the least stretch of unprotected perimeter to defend. Despite their huge size, volcanic cones are an obvious choice for a pa because the steepness of the cone is an obvious defence against attack and only the entry to the cone (the area of lava spill) needs to be defended. But most pa are built on hill-top ridges, long thin sites with a very long perimeter in comparison to their area. The obvious technique for fortifying these pa, as over time the numbers of their defenders fell, was by digging transverse ditches. These could cut a long thin rectangle into a series of squares which could be defended sequentially. Transverse ditches would have enabled a smaller number of warriors to defend a ridgetop pa. With all warriors concentrated initially in the most vulnerable square, they had the best chance of successfully defending the pa. If overwhelmed, they could retreat successively to the other squares. Digging transverse ditches allowed for the most intelligent organization of the available warriors. For example, if a ridgetop pa of 1,200 m^2 is 60 m long and 20 m wide, it has a perimeter of 160 m. If it is cut by two transverse ditches, two of the three squares, each 20 m by 20 m, have a 60 m perimeter to defend at a time and the last has 80. With a perimeter of 60 m versus 160 m to handle initially, fewer than half the men needed to defend the pa without transverse ditches could hold it against an enemy.

Clearly in any pa the addition of a second and/or third ditch and palisade also reduced the numbers needed to defend the perimeter by a half or two-thirds. Our argument is that the addition of fortifications in a context of falling populations makes sense as a means of continuing to defend optimally sited large pa – and indeed any pa – when over time there were successively fewer warriors available to defend them.

15.5 Near-Fatal Impact

The human consequences of the high rates of population decline in Little Ice Age New Zealand, obvious from sequential fortifications for pa and from our demographic analysis, show the risk of extinction increasing with time as over 356 years populations estimated in millions shrank to numbers of less than 200,000.

The arrival of European ships at a time when populations were biologically stressed and declining not only increased the risks of extinction but also undoubtedly intensified the physical and cultural impacts of contact. Populations effectively reduced by 1801 to about 8% of their numbers in AD 1445, less disease-resistant because of prolonged stress, had to combat a battery of European diseases for which they had no genetic or acquired immunity.

The highest rate of population loss for the Maori population occurred after European contact in the period from 1801 to 1858, a rate of loss from 1.72% per annum to 1.92% per annum. This is 2.4–2.5 times as high as the averaged loss rate for the total North Island population of 0.7091–0.7526% per annum we propose between 1445 and 1801. This rate dropped to 1.4% p.a. in the period 1858–1874, falling to 0.605% in the period 1874–1896. These figures are based on three censuses carried out in 1858, 1874 and 1896. We calculate that the overall loss of Maori population from AD 1770 to AD 1896 (when the census estimate for the Maori population was 42,000) was over 73–76%. But this actually represented the loss of over 70% of the 8% of the 1445 population that had survived till 1801, a total population loss from 1445 to 1896 of around 98%.

The highest decline rates during the period 1801–1858 reflect circumstances in New Zealand when, especially after the signing of the Treaty of Waitangi, European migrants flooded into New Zealand and moved away from the coastal ports, where earlier migrants had been focussed, exposing Maori in the interior to the diseases they carried. Maori deaths had increased markedly still earlier after 1819 when musket sales became more frequent, magnifying the consequences of tribal warfare. The halving of the population decline in the 22-year period between the 1874 and 1896 censuses suggests that five generations after Cook, there was growing immunity by Maori to European diseases and an improvement in nutrition and thus in fertility. Improvement in nutrition came from such sources as whale meat, available from trying stations, and the introduction of the less cold-sensitive, more easily grown, white potato.

James Belich [12] denies that the population losses suffered by the Maori from European contact had any significant cultural impact:

> Although Maori-Pakeha conflict was also a factor, these figures seem to support the notion of a Pandemic phase of high mortality in the 1850s–70s, with somewhat lower rates of decline before and after. The decline was unevenly spread across space and time, and it may have ‘crippled’ particular Maori communities in particular periods. But overall it was not crippling impact, still less fatal impact. . .The overall connection between population decline and social and cultural disintegration is almost as suspect as high population estimates. Maori suffered nothing comparable to the decline by one-third within a decade experienced by England in the mid-fourteenth century, Ireland in the mid-nineteenth, and Russia in the mid-twentieth. Why should Maori be thought to have undergone socio-cultural collapse, to have been a dying or crippled race, when European peoples who suffered even more traumatic disasters were not? The enduring myth of fatal impact is my answer to this question. The myth was strong enough not only to overshoot the evidence on Maori depopulation and to have an enduring effect on historical interpretations.

England, Ireland and Russia may have lost a third of their populations in a decade through the Black Death, the potato famine and the mania of Stalin but none of them suffered the loss of over 73% of their population following a foreign invasion that catapulted them from the Neolithic into the modern world. Maori did not trade for pretty beads. They traded for muskets and used them to annihilate their traditional enemies. The opportunism, the readiness to seize new opportunities as they arose – a major survival strategy for Maori throughout their Neolithic history – opened a Pandora’s box of destructive possibilities. The escalation from Neolithic hand-to-hand combat to “modern” warfare catapulted a warrior society into a see-saw of attacks and retributions, of killing and being killed, on a scale outside traditional experience and, once initiated, outside their scope to contain. The catapulting of a

Neolithic culture into a modern world which possessed destructive possibilities so far outside traditional experience and knowledge brought dangers as extreme to the Maori as their contact with the invisible European diseases. The near-fatal impact was biological, military, cultural and psychological. It caused an undermining of the beliefs and of the social and traditional practices that had given certainty to their world. Rapid forced adaptation was the only hope for survival and probably few could meet its demands.

Belich claims that the "enduring myth of fatal impact" was strong enough both "to overshoot the evidence on Maori depopulation" and to propagate the myth that Maori had "undergone socio-cultural collapse". Belich's claims were made without the advantages of the demographic insights that follow from our revised analysis of skeletal data in the last chapter and from correlations in 1445 of estimated pa populations with new data-based estimates for pa capacity. He had no knowledge therefore of the severe demographic losses of the order of 92–93% suffered by Maori populations between 1445 and 1801 – a figure which we have seen increased to around 98% by 1896. Analysis of the demographic patterns involved makes it impossible to ignore the catastrophic consequences for the Maori world of climate-driven population collapse followed by the near-fatal impact of European contact.

The survival of any tribal history and traditional knowledge is remarkable after such a loss and suggests the robustness of the systems of traditional learning and the transmission of oral traditions in place at the time of European contact.

15.6 Summary of the Demographic Evidence in Part II

In Part II we have proposed and illustrated a context of climate-driven demography linking high populations exposed to resource depletion, due to climate stress, with starvation, warfare, cannibalism and population collapse. We have demonstrated the relevance of this context from demographic patterns in northern Europe with populations increasing significantly in the Medieval Climatic Optimum and then suffering extreme decline in the Little Ice Age, with repeated crop failures leading to widespread starvation and with cannibalism a measure of desperation in the starving. We have shown more complex and persisting examples of climate-driven demography operating in tropical Polynesia, North America and New Zealand in the same climate periods. We have set evidence for starvation and cannibalism and for conflict over land and resources in New Zealand in a global context in which the warmest period in over 2,000 years was followed by the coldest conditions in 1,800 years and in which catastrophic population losses occurred almost worldwide.

This material has provided a context in which to read the demographic evidence presented in Chapter 14. A modern statistical analysis of the skeletal evidence, studied by Brewis, Molloy and Sutton, gives explicit quantifiable evidence for drastic population loss in the poorer areas in Little Ice Age New Zealand.

New evidence from field archaeology relating to Maori pa has made it possible to estimate the total population capacity of pa in 1445 and to use this with Rutherford's and Urlich's population estimates for 1801 to determine differential rates for population decrease in the richer areas (about 50% of that in poorer areas). This has enabled us to offer a comprehensive overview of the demographic patterns shaping the prehistory of New Zealand from 1445 to 1896. That the differential rate of population decline between pa and non-pa areas is so great highlights the efficacy of growing and storing kumara to combat starvation. That is, it supports the role of horticulture and pa-building as strategies for survival.

Our overview confirms the appropriateness of our studying demographic evidence implicit in Maori pa in the context of a rapidly falling rather than a steadily increasing population. The implications of this approach are profound. We have argued that a rapidly increasing population is crucial to the theory of a late first settlement. A rapidly falling population presupposes a very high earlier population which, in its turn, indicates a long time depth for Maori prehistory and demography. Pa evidence read in the light of falling populations establishes definitively that a late first settlement date for New Zealand is out of the question.

In demonstrating the consilience of the evidence on which these interpretations and consequences depend, we have drawn on many sources of evidence and provided new contexts in which to view old evidence. Statistics, climatology, skeletal analysis, a power law analysis and field archaeology have all played a part. The demographic evidence we present and the conclusions we reach are startlingly different from any in the discipline. They paint an extreme and disturbing picture of climate-driven catastrophic population loss extending over 400 years in the richer areas. In some less well resourced areas, a rate of decline twice that in the richer areas would have driven some populations quickly to extinction. The arrival of Europeans involved a near-fatal contact, with access to muskets intensifying the consequences of tribal warfare and European diseases reducing what was already a remnant population to less than 2% of what it had been at the beginning of the Little Ice Age.

The demographic evidence we present and the interpretations we propose support the inescapable conclusion that the first settlement of New Zealand took place close to the beginning of the Lapita colonizing period from 3,600 to 3,000 years ago.

This conclusion has considerable consequences. It changes the way we perceive the earliest phase in the peopling of the Pacific. A Lapita-age first settlement of New Zealand assumes a significant place in early Pacific prehistory and in the history of oceanic migration. Evidence for a Lapita-age first settlement of New Zealand, moreover, validates the paradigm proposed in Part I for two waves of exploration and settlement by Spice Island mariners in two oceans, following three of the four major warm currents flowing out of the West Pacific Warm Pool. Our demographic analysis makes it clear that first-wave explorers and colonists reached New Zealand long before the cold period that began in 1000 BC. It also confirms the principles we have suggested as underlying both first- and second-wave Spice Islanders' choice of exploration and sailing strategies and migration routes. These include the limiting of long-distance migration to global warm periods; avoidance of west–east sailing against the trade winds and currents in the southern Pacific; and accordance with a leap-frogging strategy determining settlement sequence in which the largest and most promising lands were colonized first regardless of distance so long as there were fast ocean roads for reaching them, with less desirable lands in between being colonized much later.

We argue that the chosen exploration strategy of following three of the four major currents out of the West Pacific Warm Pool made possible a comprehensive, swift, early colonization of the largest and best uninhabited islands in the Pacific and Indian Oceans. An early discovery of New Zealand could be predicted from this exploration strategy alone. For with the tendency of strong currents to turn towards a landmass, the largest lands would be the easiest to find. New Zealand as the largest landmass in the Pacific would have been both readily discovered and tempting to settle early. Its size was three times that of the Spice Islands. It possessed rich protein resources such as moa and seals unknown either in the Spice Islands or in Island Melanesia.

The early prehistory of New Zealand can be seen to emerge from and to belong to the far older prehistory we have proposed for the Spice Islands. It can also be seen as belonging to and forming a significant part of the earliest phase in the settlement of the Pacific. Though the first settlers in New Zealand are usually cast as the most recent Pacific migrants, seen instead as Lapita-age first settlers they take their place amongst the earliest Pacific pathfinders and pioneers.

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Chapter 16
The Context of Oral Traditions: The Oral Transmission of History and Maui the Navigator's Visit to New Zealand

Abstract The early settlement of New Zealand is implicit in traditional accounts of Maui the Navigator's visit to New Zealand. It is clear from these accounts that Maui followed sailing instructions handed down from earlier navigators. The language divergence and cultural impoverishment of the indigenous peoples he met point both to a significant time depth since first settlement and to long isolation for the descendants of the first colonists. Following the East Australian Current led Maui to a landing on the west coast of the South Island, the landfall predicted by our paradigm and recorded in traditional histories. Maui's "discovery" of the North Island, together with the descendants of earlier migrants, emphasizes the isolation of New Zealand from its Spice Island homeland since knowledge of the North Island had not reached the Spice Islands in 1,500 years. A matrilineal social structure obvious from Maui's meeting with a chieftainess at Orokoroko matches evidence presented in Chapter 10 for the preservation of early matrilineal structures in New Zealand. Further, the fact that news of Maui's death was brought back to New Zealand and preserved there supports traditional evidence for later colonizations of New Zealand spanning 1,300 years by Maui's descendants claiming land rights in his name.

Keywords Oral traditions · Maori legends · Myth and Prehistory · Language divergence · Technological impoverishment · Maui's visit to New Zealand · Lapita origins

16.1 Introduction

In this and the following chapter we move from the relative certainties of mathematics to more subtle and indirect evidence for a Lapita-age first settlement of New Zealand. We offer evidence for a first-wave settlement of New Zealand from Maori oral traditions. We focus in this chapter on traditional accounts of a singular event, Maui the Navigator's visit to New Zealand and his meeting with the chieftainess of Orokoroko at Palliser Bay. From the chronology we derive in Chapter 19 it seems likely that this visit took place in about AD 100.

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The probably insurmountable problem of finding archaeological evidence for early settlements in New Zealand can be illustrated from the erosion history of Palliser Bay, a shallow bay on the southern coast of the North Island. This bay is especially subject to damage from erosion. Walters and Goff record that at Palliser Bay the AD 1450 tsunami penetrated 3.5 km inland with "erosion of coasts for about 1.5 km. landward" [1]. The preceding nationwide tsunamis of AD 200, 500, 950 and 1220 may have eroded the bay as savagely. It is highly unlikely that artefactual evidence for the early settlement that is described in the traditional accounts that we consider in this chapter will ever be found. A continuing cumulative destruction or deep-burying of archaeological evidence is inevitable in a country as subject to climate-induced and tectonically caused erosion as New Zealand. With artefacts from such sites unlikely to be discovered, traditional histories may provide the only window on their history. Accounts of Maui's encounter with the chieftainess of Orokoroko provide unexpected historical detail and insights. These challenge the limiting assumptions that only archaeological evidence is valid and that the absence of archaeological evidence is proof that no early indigenous history exists.

16.2 Oral Traditions

Oral traditions offer fleeting glimpses of a past that is often hard to snare in any material or defensible way. Many academics sheer away from uncertainties lest they blight their reputation for "soundness". This academic response to traditional histories is reflected in Margaret Orbell′s *Hawaiki, A New Approach to Maori Tradition* [2]. Orbell expresses the deep discomfort many prehistorians now feel with oral traditions. She notes that some recent events recorded in Maori tradition may have a historical component but believes older events are purely mythological. And that earlier prehistorians like S. Percy Smith and Abraham Fornander have missed the point of purely mythical oral traditions and have headed down the slippery slope of seeking prehistory where none exists. In this chapter we contest Orbell's conclusion that it is a pointless task to seek history in myth.

Writing systems are said to be only 5,000 or so years old, that is, they have been a chosen means of remembering for a literate few for only 5% of the last 100,000 years. Oral traditions have preserved and passed on vital knowledge from one generation to another throughout human history. Because the transmission of knowledge is so important for physical and cultural survival, the human brain appears to have evolved to ensure its success. Modern studies of the brain through MRI imaging show it developing in response to the demands placed on it. They show successive phases of proliferation and pruning of neural connections based on a "use it or lose it" basis. If navigational memorization is a priority, the posterior hippocampus (a part of the brain involved in spatial memory) will enlarge to meet the need. MRI scans of the brains of London cab-drivers, who are required to memorize all the streets of London, for example, reveal an unusually enlarged posterior hippocampus compared with controls. The authors of an MRI imaging study of London cab drivers [3] note that small mammals and birds who engage in behaviour requiring spatial memory also show increases in hippocampal volume relative to brain and body size and that in some species this enlargement is seasonal when demand for spatial ability is greatest. They comment that their London cab driver data "are in accordance with the idea that the posterior hippocampus stores a spatial representation of the environment and can expand regionally to accommodate elaboration of this representation in people with a high dependence on navigational skills". They add that "It seems that there is a capacity for local plastic change in the structure of the healthy adult human brain in response to environmental demands."

In prehistoric Polynesian societies, children were trained from a young age to memorize vital information and those with the greatest aptitude were chosen to be more intensively trained for a role in the transmission of specialized knowledge. Knowledge of astronomy and navigation, for example, were vital to a maritime society and those with aptitude were given rigorous and extensive memory training and then years of practical training so they could become the navigators and teachers of the next generation.

What the young brain grows to master and how it physically develops depend on the cultural priorities it is presented with. In a prehistoric society when 30 might be an average life span, transmission of knowledge vital to survival has an especially high priority. Knowledge such as how to handle problems in childbirth, how to make fire, how to make cloth from paperbark or build a canoe has to be scrupulously preserved and passed on from one generation to the next. Historical and genealogical knowledge will also be carefully preserved by a society in which the deeds of ancestors have a high cultural value and at a practical level define hierarchical structures, land rights and the status of individuals within a tribe. The transmission of specialized knowledge essentially involved apprenticing a young person to a master. This is perhaps comparable with the modern provision of higher education to ensure continuity in the transmission of technological knowledge and skills. Interpreting Polynesian oral traditions enshrining historical events and the deeds of ancestors, however, requires an understanding of the poetic or story-telling medium and a special understanding of the rich metaphorical context in which historical events are perceived and presented.

16.3 The Interface Between Myth and History

The advances made in the late 19th and 20th centuries in the study of anthropology, mythology and comparative religion have inevitably changed the historian's focus in interpreting early written and oral sources for prehistory. Emphasis is placed on the need to grasp something of the mindset of those framing and transmitting cultural knowledge through myth, legend and history. Where Maori tradition is concerned, this involves recognizing the poetic power and richness of Maori metaphorical thinking and the use of legend, metaphor and language itself for encoding important knowledge and for creating a literary embodiment of cultural priorities.

But Polynesian myth and legend are not simply history heavily disguised: history is not the pearl in the mythical oyster. Rather history is seen as the re-enactment of myth, a recreation of mythical patterns. Traditional modes of thinking about exploration, for example, are represented in terms of the central metaphors which belong to the mythology of creation. Explorers discovering new lands are seen as successive Mauis fishing up lands from a primal ocean, engaged like Maui the demigod in the process of creation itself. The mythical hero and the historical hero are handfast because myth and legend are seen as a living force. When metaphorically he fishes up new lands, an historical explorer draws on or partakes of the *mana* (spiritual power) inherent in primal creation: he helps to ensure the continuation of that creation and he draws some of that mana to himself and to his descendants.

16.4 Exploration and Settlement in the Context of Global Climate Patterns

While oral histories telling of Maui the Navigator's visit to New Zealand need to be read in this mythological framework, they can also be viewed historically in the light of global climate history. That is, they can be seen in a context where fluctuations in global climate generate a recurring pattern of conditions favouring or limiting possibilities for exploration and migration. Viewed in this way, Maui's explorations of the Pacific belong to a worldwide pattern of exploration and colonization confined to warm climate periods. Global climatic conditions constrain the dating of Maui's visit to New Zealand.

H.H. Lamb [4] sees not just the history of maritime exploration but more generally of all human exploration and migration as being firmly tied to global warm periods. He presents the Indo-European migrations that led to the peopling of Europe, for example, in this context. He also illustrates this theme by describing two sets of parallel and extraordinary feats of oceanic exploration and colonization belonging to the Medieval Climatic Optimum. In the Pacific Polynesian explorers discovered or rediscovered, colonized or recolonized the major archipelagoes in the Pacific. In the northern Atlantic, Norse Vikings, in wonderfully constructed and decorated ocean-going ships, not only traded as far as Byzantium, plundered coastal areas and supplied Europe and their own colonies with Irish slaves, but "discovered" and colonized Vinland (in North America). One Viking ship, Lamb tells us, is reported to have sailed along the west coast of North America as far as the Californian Gulf. Oral traditions amongst the native Americans there recall the event because of the fair skin and red hair of the Norsemen [5]. Reduced reach of ice in the North Atlantic, reduced storminess and clearer skies (making navigating by the stars easier) facilitated both exploration and colonization in the medieval warm period. A greater range of crops could be grown at the time of the colonization of Iceland, Greenland and Vinland than today; grass was lusher, cod swarmed in the northern seas.

Lamb makes the point, however, that these Norse medieval explorations and colonizations were but the latest in a series of explorations and colonizations belonging to warm periods, with the discovered lands often forgotten or only dimly remembered in intervening cold periods. In their newly discovered lands the medieval Norse colonists found earlier settlers, who had settled there in an earlier warm epoch which had also favoured exploration and colonization. Lamb tells of one such early group of migrants who had discovered and established colonies in both Greenland and Iceland 400 years earlier than the medieval Norse colonists. They claimed to have been sent by King Arthur in AD 531 to seek and settle lands to the north of Scotland. From the point of view of climate, AD 531 was not a good time for exploring and settling in the North Atlantic. Perhaps this is borne out by the oral record that five of their ships were destroyed and half of the 2,000 colonists (which included 400 women) drowned on the way. Surprisingly, these much earlier colonists recounted that they had also met inhabitants already established in Iceland who "warned of dangerous seas and currents farther north". Lamb adds, "If there is any substance to these reports, this earlier population in Iceland must have died out between that time and 790–860; the epoch is thought to have included a marked cold period. A party of Greenlanders, however, who reached Norway in the deteriorating conditions of the late fourteenth century, in AD 1364, knew of the legend and claimed to be descended from these first immigrants" (p. 252).

King Arthur is often regarded as a figure of myth rather than an historical figure. Often Maui the Navigator in Polynesian oral traditions is similarly dismissed and confused with the mythical demi-god whose name was conferred on him. This is hardly surprising. When long cold periods inimical to ocean voyaging isolate distant colonies, and earlier explorers and colonists are a distant memory in their original homeland, a story told round a fire at night, the lands they discovered are effectively lost, waiting to be rediscovered when a warm period conducive to ocean voyaging occurs again. In some cases the wait might be as long as a thousand years. The scenario is as probable for New Zealand and Easter Island as it is for Greenland and Iceland and Vinland. Each set of colonists will preserve in their own oral traditions memories of their voyage to the new land, memories of the navigator and captain of their ship or canoe and a record of their descent from those aboard. Memories of their former homeland will fade as it becomes less relevant to their new isolated lives. And those in the former homeland will even more quickly forget the people who left long ago and never returned and so have no place and relevance in their world.

Viewing Maui's explorations of the Pacific, carrying him south to New Zealand and as far north as Hawaii, in this light, provides a context for his discovery of the North Island of New Zealand, replete with its inhabitants, and also for his fishing up of the island of Maui in the Hawaiian Group. In terms of our paradigm, Maui was a second-wave explorer who followed two of the four powerful warm currents flowing out of the West Pacific Warm Pool. Clearly Maui inherited sailing instructions for reaching the South Island by following the East Australian Current south till it turned in response to the landmass of New Zealand and took him to a landing on the west coast of the South Island. It seems probable that knowledge of the long-ago founding of a colony in the South Island of New Zealand was preserved amongst his people in the Spice Islands. Maui, following a known ocean road, reached the South Island first and expected to find it where he did. His discovery of the North Island was altogether different. His people had not passed on any knowledge of it to him. It was Maui therefore who claimed to have fished it up from the ocean and so earned, for himself and his descendants, rights to the land he had discovered.

These two enriching contexts, one mythological, the other related to climate-modulated maritime exploration and colonization, enable us to appreciate the historical events represented in the traditional histories celebrating Maui's visit to the South Island and his discovery of the North Island. But it is from the fine detail in the traditional accounts that we gain most insight and can find subtle implicit evidence for a Lapita-age first settlement of New Zealand.

16.5 Maui the Navigator's Visit to New Zealand

Accounts of Maui the Navigator's visit to New Zealand, recorded by Herries Beattie [6]and John White [7], offer us information in a range of different ways. First, at the simplest level, there is the account of what happened: the landing of Maui's canoe at Mahitahi (Bruce Bay) on the west coast of the South Island, Maui's progress along the west and south coasts of the South Island and then up the east coast, Maui's climbing of a hill in the north of the South Island and thereby discovering the North Island, his first landing on the North Island and his meeting with the chieftainess at Orokoroko in Palliser Bay.

A great deal of historical information can, however, be gleaned from the narrative detail embellishing this straightforward account. The account begins traditionally as a hero's tale. It tells of Maui seeking to avenge the humiliation suffered by his father through defeat in an encounter with two marine monsters. But this is no simple "St George and the Dragon" folktale. The names of the two monsters encode historical events underlying the mythical narrative.

It is important to note here that the Polynesian languages derive much of their poetic and metaphorical richness from the fact that they are agglutinative. That is, their words are formed from morphemes, usually single or double-syllable words that retain their original forms and meanings with little change during the process of combination. This means that a great deal of meaning is inherent in a word which can draw upon the full suggestiveness of all the elements from which it has been formed. The examples we offer will illustrate the principles involved and show how information can be encoded in the names and language used.

Metaphorically, Maui's father's two enemies are *mako*, tiger sharks. Their names are given as Mako-tipua and Mako-horopekapeka. The second part of the first tiger shark's name is *tipua* which carries meanings of demon, sorcerer, wizard as well as of voracious attacker, possibly suggesting that this metaphorical tiger shark might have represented the *tohunga* (shaman) of the war party that attacked Maui's father's people. The composite name of the second tiger shark, Mako-horopekapeka, confirms this suggestion, encoding the humiliation of a military defeat. *Horo* is to fall or be taken, as a fortress, to fall in fragments, to crumble down. *Pekapeka* is to be opposed to, to quarrel and also to be punished for little or no crime, to be in bonds, to suffer as a prisoner, to have one's hands bound behind one's back or to a post or to be driven away.

The defeat of the two "tiger sharks" by Maui, the hero, and revenge for the humiliating defeat of his father is, of course, the expected outcome in a hero's tale. And indeed the very name of the axe with which Maui slew the two sharks celebrates this triumph, for the axe is called *Tihe-mauri-ora*. *Tihi* can be translated as to sneeze or snore but also to arrive, to appear, the second translation, Tregear informs us [8], embodying the general notion that the spirit has returned after wandering. *Mauri* is the heart, the seat of the emotions, the soul, life. *Ora* carries all the implications of life, good health, of being whole and sound and safe and also of having escaped, of being recovered. Tregear tells us the name of Maui's axe is repeated when someone sneezes as a charm to ward off evil spirits, the equivalent of the English "Bless you!"

But Maui's setting out in search of new lands following his winning this battle in his homeland suggests he was conscious that he had won a battle but not the ongoing war against two sets of powerful enemies. Migration for the defeated appears to be a looming possibility that he has to prepare for on behalf of his people.

We have already discussed conflict and defeat-driven migration in the Spice Islands as possible factors leading to the migration to Madagascar, to migrations within Island Southeast Asia and to two early migrations to Hawaii. Oral traditions tell us that Maui's visit to New Zealand was part of a more comprehensive exploration of the Pacific which included a voyage to Hawaii, said to have occurred after his visit to New Zealand.

At one level, then, the tale of Maui's visit to New Zealand can be seen as encoding historical events – invasion, warfare, defeat for Maui's father followed by Maui's recent triumph in battle. It does so in a traditional tale celebrating a hero's triumph over traditional enemies. This heroic tale, however, gains force from the mythological context in which Maui's discovery of the North Island of New Zealand is presented. Through his fishing up of the North Island, Maui becomes more than a hero, navigator and explorer. Metaphorically he becomes Maui the demi-god drawing up the first land from the sea in a primal act of creation. The extraordinary mana accruing to him from this act belongs not only to himself but also to his tribe and to his descendants. Mana is seen as being drawn from other levels of reality through Maui's daring and success. In tradition, both myth and *karakia* (invocations) straddle different realms, different levels of reality, and can bring about a transference of mana from ancient mana-filled events, places and people to the present, harnessing that mana for the living. Thus the story of Maui's discovery, his fishing up of the North Island, is not just a narrative embellishment of an historical event. It is a fundamental claim by the historical Maui the Navigator to a primal acquisition of personal and tribal mana. As discovery entails land rights and as status is inherited, this has direct, practical consequences for Maui and his descendants.

Maui's landing on the West Coast of the South Island confirms that the sailing instructions that he had received, or inherited from, first-wave explorers followed the

East Australian Current. This flows past New Caledonia parallel to the east coast of Australia. Eventually, in response to the landmass of New Zealand, it reverses its southerly direction and turns north to flow along the west coast of the South Island. There, according to tradition, Maui made his landing at Mahitahi (Bruce Bay) and there, according to traditional accounts, he saw in the hills the fires of the "wild men of the woods", evidence that descendants of first-wave colonists still survived in the South Island. These people he probably expected to see if his sailing instructions had been handed down from the Lapita-age explorers who first discovered the South Island and prompted its settlement.

What Maui did not expect to find was the North Island and its inhabitants. It is clear from all accounts of his visit that this was a totally unexpected event. Maui's travels along the south and east coasts of the South Island are carefully detailed – marked by place names tracing his route and honouring members of his crew. The southern Alps, for example, were named Tiritiri-o-te-moana, named for Maui's misinterpretation, as his canoe drew towards Mahitahi, of the sight of snow on the Alps as "a mirage of the ocean". Herries Beattie [9] lists the many place names that authenticate the route of Maui's coastal journey in the South Island:

> The high bunch round Mount Cook was called Aotea, and the foothills Puke-maeroero (hills of the wild men of the woods)...[at] Big Bay where a hill was named in memory of the axe which slew the marine monsters, this axe being called Tihe-mauri-ora...Along the northern shore of Foxeaux Strait we get the names Okui, Oue and Kai all considered to be connected with Maui's voyage...His own name is perpetuated in O-maui Beach at Port Adventure, Stewart Island, O-maui Cliff at New River Heads, Maui Rock near Waikouaiti, Maui near the mouth of the Opihi River, O-maui, a coastal rock near Akaroa Harbour...An intriguing name was that bestowed on the Moeraki Peninsula, Te Raka-a-Hine-atea, named after Maui's father Te Raka, and the latter's mother Hina-atea [Maui's paternal grandmother]. ...Coming to Kaikoura Maui climbed a hill and from there saw or 'fished-up' the North Island. That hill was his 'taumanu' or fishing station, and if the South Island is called Te Waka-a-Maui (the canoe of Maui) that hill is Te Taumanu-a-Maui [Maui's fishing station].

16.6 Maui's Meeting with the Chieftainess of Orokoroko

The detailed place names add authenticity to the traditional accounts. But it is the details Beattie quotes from his South Island informants about Maui's meeting with the chieftainess of Orokoroko that are most fascinating:

> South Island tradition says the part of the North Island which Maui first came to was Orokoroko, and when comparing that part of New Zealand to a fish, Orokoroko point is said to be the tip of the nose. A North Island tradition about Maui's fish (A.H.M. II, p.114) says that its upper jaw is the Orongorongo Point, its lower jaw was Te Rimurapu and its forehead was Turakirae. All my informants laid stress on the fact that as Maui drew near his 'fish' he saw a village on shore, men were fishing off the coast, smoke was ascending from the whares (houses), women were calling to each other, dogs were barking, and children playing about. The largest house in the kaika (village) was occupied by a woman, the chieftainess, and she was the head person of the community. She met the canoe and it

> was found that their languages were sufficiently alike for Maui and she to have some conversation (p.154).

Beattie gives further details of Maui's stay in New Zealand:

> From Orokoroko, Maui proceeded up the East Coast and is next mentioned at Hawke's Bay where a point of land to the south of the harbour is known as Te Matua-a-Maui (the fish hook of Maui). Gathering information from the Maoris about 1894, Colonel Gudgeon was told that Maui had lived at East Cape. This is quite possible but it was presumably only for a brief period. Then we have Maui's name mentioned in connection with White's Island and its volcanic fires, and finally he is said to have left the Kui family near the North Cape.

Beattie goes on to quote from a North Island (Ngapuhi) account which, offering us a remarkable window on the past, records Maui's response to the inhabitants of his "fish":

> When Maui saw the people who inhabited the land he had fished up, he attempted to teach them; but they were a very stupid people, and did not learn the lessons he taught. He was therefore angry, and said: 'It is a waste of light for the sun to shine on such a stupid (moho) people.' One of the meanings of moho is stupid but it can also mean a forest dweller, a bushman, and mohowao or mohoao signifies a wild man of the woods, a barbarian.

Beattie then speculates:

> Who were these inhabitants mentioned in the various vivid narratives? I made inquiries about them and as far as my chief informants knew these people were of the same race as the Maoris – that is they were a brown people, Polynesians. If Maui could talk with the principal woman at Orokoroko, even with difficulty, it implies that she spoke an early form of the Polynesian language. They are said to have been a tall people and the men were capable fishermen. Their huts or whares were of the traditional Maori type, and the fact that the chief personage at Orokoroko was a woman argues that they had a certain culture, and that women had a responsible position among them (p. 155).

It is significant that Maui never claimed to have discovered the South Island and that he claimed no land rights to it. The existence of the North Island was clearly unknown to his people. His discovery of it, in his own eyes and those of his descendants, thus brought mana and land rights with it. Maui left Kui at North Cape as guardian of those land rights. It seems likely that some of the crew of the two exploratory canoes Maui led may have formed a small colony there for tradition tells us that the "people of Kui" were still living at Kaipara when Nukutawhiti landed there [10] (750 years later according to the chronology we suggest in Chapter 20). It is unlikely that any women were aboard Maui's two exploratory canoes. The men left by Maui to protect his land rights at Kaipara, a large harbour on the west coast of the North Island north of Auckland, must therefore have intermarried with women from indigenous tribes.

New colonists followed in Maui's wake. Maui's son Wi-Wi, who, judging from South Island places named after crew members, accompanied Maui on his visit to New Zealand, led a later colonizing expedition to New Zealand, as did Wi-Wi's own great-grandson, Tutumaiao, in turn. Six hundred years later, Rakaihautu, also descended from the Maui who visited New Zealand in the traditional accounts above, came to New Zealand presumably also to claim land rights in the name of his ancestor. Finding the North Island already well settled, he established a colony in the South Island. Nearly 600 years after Rakaihautu, Turi, leader of the *Aotea* canoe of the *Heke*, likewise claimed descent from Maui and claimed the land rights he believed this entailed.

16.7 A Lapita Rat at Orokoroko

Some of the details in the account of Maui's meeting with the chieftainess of Orokoroko in Palliser Bay have direct implications for our claim of a Lapita first settlement of New Zealand. Even the name Orokoroko ("for the very first time") suggests it may have been one of the earliest settlements in the North Island. If this is the case, the discovery in the Washpool Midden of bones of the Pacific rat, *Rattus exulans* belonging to haplogroup IIIA, which has a Lapita distribution, might be seen as confirmation for the possibility that Orokoroko was once a Lapita-age site, or more probably a secondary colony established from a New Zealand Lapita-age colony.

As we have reported, Elizabeth Matisoo-Smith and J.H. Robins [11] have studied the mitochondrial DNA of the Pacific rat, *Rattus exulans*, carried by the Lapita peoples and their descendants all over the Pacific as a food animal. From study of the haplogroups of this animal, they have cast new light on the origins and migration sequences of Lapita peoples and their descendants. In a midden in Palliser Bay, where Maui met the chieftainess of Orokoroko, Matisoo-Smith and Robins found the bones of a Pacific rat belonging to haplogroup III A. Although late settlement theorists see Eastern Polynesia as the sole source for both Maori and for New Zealand Pacific rat genes, this rat haplogroup occurs nowhere in Eastern Polynesia. It occurs only in Lapita colonies in Vanuatu, New Caledonia, Samoa and Fiji and in Micronesia. Finding this Lapita rat haplogroup in New Zealand could be seen as archaeological evidence either for a Lapita-age settlement of New Zealand or for a very early settlement of New Zealand from Western Polynesia. But there is the additionally interesting fact that the Lapita rat haplotype found in New Zealand (haplotype 22) differs from that found in the Lapita colonies of Western Polynesia (haplotype 15). It seems possible from Matisoo-Smith and Robins' unrooted NJ tree that haplotype 22 mutated in New Zealand from haplotype 15. If adequate time is allowed for such a mutation to have independently occurred in New Zealand, this adds to the likelihood of a very early, probably Lapita-age, introduction of the rat.

Evidence that a Lapita rat haplotype may have undergone mutation in New Zealand recalls the evidence, discussed in Chapter 5, for a mutation 2,000– 3,000 years ago of the Japanese taro probably in New Zealand. With a chromosome count of $2n = 42$, compared with that of the Eastern Polynesian taro ($2n$=28), and a different history of diffusion, the presence in New Zealand of the Japanese taro is as anomalous as the Lapita rat haplogroup in Palliser Bay unless the possibility of a Lapita-age first settlement is acknowledged and long previous Spice Island contact with southern Japan seen as the likely source for the New Zealand Japanese variety.

Evidence for mutation of nearly half of the existing Maori maternal haplotypes (discussed in Chapter 20) has the same implications for a long presence in New Zealand of Maori.

16.8 The Death of Maui the Navigator

The story of Maui's death after his return to his own country has an historical as well as a mythological import. Two apparently contradictory versions of Maui's death, which Beattie could not reconcile, persist in New Zealand. It is possible that in one case we have a historical event presented simply, in the other the same historical event presented in a mythological frame. The simple historical event has Maui the Navigator drowned in a tidal wave in a narrow strait close to his homeland. The mythological frame is provided by a myth, which is unique to New Zealand [12] – a myth in which the demi-god Maui sets out to achieve immortality for man by defeating Hine-re-te-po, the goddess of death, by penetrating and passing through her body, metaphorically destroying the power of death from within.

Tradition tells us that Maui met his death at a place called Te-one-ki-pikopiko-i-whiti [13]. Let us consider the suggestive force of some of the elements that make up this place name. *One* is the beach, the shore; *ki* means full, filled up, tight, and also high (of the tide); *piko* means to bend, stoop and a bend, a corner. *Whaka-piko* means to go alternately in opposite directions; *tapiko* is to set a trap, murder committed in breach of hospitality and also to be wrong morally, crooked, bent and also to be vanquished or overcome, to be extinguished. *I* is to ferment, turn sour, or anything indicating age or decay. *Whiti* is to cross over, to get to the other side of a sea or river and also means the extremity of a place or thing.

"To cross over the sea" and "high tide on the curved shore", suggestions inherent in the name of the place where Maui died, suggest an historical event, his drowning in a tidal wave in a curved narrow strait, one traditional explanation of his death, according to Beattie [14]. As we have noted, Maui, according to our calculations (part of the chronology we develop in Chapter 19), visited New Zealand about AD 100. It is conceivable that the volcanic eruption at Ambrym, Vanuatu, which blew the island apart probably about AD 100, could have generated the tsunami in which Maui drowned. In Chapter 20 we are, in fact, able to use climate proxy data to confirm this dating for the Ambrym eruption.

Another set of meanings for the word *piko* is related to murder and death, age and decay. *Piko* means to be morally wrong, to set a trap, to commit murder in breach of hospitality and also to be vanquished or overcome, to be extinguished. In this metaphorical interpretation, the curved narrow strait where Maui the Navigator is trapped by a tidal wave can be seen as a metaphor for the demi-god Maui's tight passage through the body of the goddess of death. In this interpretation the mythological element of the story of Maui's death, an explanation for man's mortality, is woven into the tragic story of a hero's defeat in a heroic battle against impossible odds, the quest to steal immortality for man from the goddess of death herself.

16.9 Evidence for an Early First Settlement from Language Divergence

Directly related to our claim for a Lapita-age first settlement of New Zealand, is Beattie's mention of a language divergence existing between Maui and the chieftainess. Both the Ngati-hau and Ngapuhi, North Island, accounts (recorded in John White's *The Ancient History of the Maori* [15]) tell also of the technological impoverishment of the Orokoroko people compared with Maui's people.

There is one comparable instance of long-term linguistic isolation in Polynesian prehistory, that of Rapanui (Easter Island). Accounts are given of the linguistic distance of Rapanui speech from Eastern Polynesian by two early European visitors, Captain James Cook in 1774 and Hugh Cuming of the schooner *The Discoverer* in 1827. Steven Roger Fischer, discussing a manuscript recording Cuming's visit [16], comments:

> Of singular linguistic interest is the comment (MS p.9) that the 'Pomotian' (Paumotuan, later form: Tuamotuan) on board the Discoverer was quite unable to hold conversation with the Rapanui, although he could understand 'a few words they spoke.' The only similar linguistic experiment on Rapanui at such an early date was that by Cook in 1774, evidently with similar futility.

Fischer adds in a footnote (p. 312) "Cook in 1774 (1777: 1: 278) notes that the language of the first Rapanui to board 'was, in a manner, wholly unintelligible to all of us' and also to their official translator, Otiti (whom Fischer tells us was actually Mahine, a minor chief of the Society Islands), who, Cook continues (p. 293) 'understood their language much better than any of us, though even he understood it but very imperfectly'."

If Easter Island were first settled in AD 400, as Fischer suggests, there would be a time gap of 1,374 years from first settlement to Cook's arrival and 1,427 years to that of *The Discoverer*. It is possible, however, that the Easter Island's isolation was not absolute throughout this period. Evidence from genealogies suggests that Hotu Matua's settlement was secondary and occurred during the Medieval Climatic Optimum. Katherine Routledge claims that there is evidence from Mangarevan tradition of Hotu Matua's departure for Easter Island in this period from Mangareva [17]. There would undoubtedly have been some later Eastern Polynesian linguistic input from this migration and perhaps also from the visit of Tangi'ia, who, according to Rarotongan tradition [18] perhaps about AD 1294, sought his adopted son there. We note that if recent arguments for a primary, as opposed to a secondary, colonization of Easter Island in the Medieval Climatic Optimum [19] are given credence, the linguistic divergence recorded above would be anomalous.

In comparison to these gaps of 1,374 and 1,427 years, there is, by our estimate, a gap of perhaps 1,500 years between a Lapita-age first settlement of New Zealand and Maui's visit at about AD 100 (see Chapter 20). From climatic evidence there were probably 600 years of total isolation during that time in which long-distance voyaging to New Zealand would not have been possible and another 400 years of relative isolation before Maui's visit. The situations of New Zealand and Easter

Island, if not identical, are certainly comparable and, not surprisingly, in both cases there is a record of linguistic distance attributable to long isolation.

There are some interesting similarities between accounts of Maui's visit to New Zealand and that of the Eastern Polynesian navigator Toi. The timing for Toi's visit is unclear. The motivation for Toi's visit to New Zealand is well known. Toi's grandson Whatonga and his nephew Turahui were blown out to sea in a sudden storm and lost during a canoe race said to have taken place in the islands of Oahu and Maui in Hawaii [20]. After searching in vain for his grandson and nephew in Eastern Polynesia, Toi sailed with 40 men to New Zealand in search of them. He landed at Whakatane in the Bay of Plenty on the east coast of the North Island. A conceivable interpretation of the curious fact that the canoe race was held in Hawaii, not their home base of Rarotonga, suggests the possibility that Toi and his grandson may have been involved in one of the simultaneous southern migrations to Hawaii from several archipelagoes in the southern Pacific during a time of a severe drought, which we date to 1096 in Chapter 19. If they had been involved, it would give a reason for Whatonga's taking part in a canoe race in Hawaii. More significantly it might explain why Toi and his men decided to settle in New Zealand once they had reached it, rather than to return to their drought-ravaged homeland in Rarotonga or to return to Hawaii, where colonists from the competing migrations would already have chosen the best sites.

In the account of Maui's visit to New Zealand it is implied that communication between Maui and the chieftainess of Orokoroko was difficult but possible. In traditional accounts of Toi's visit, it is claimed that Toi's language and the language of the indigenous tribes of the North Island were mutually incomprehensible [21]. And yet from recorded examples of differences between the two languages [22] it is clear that the tangata whenua spoke a Polynesian language. For example, the early tangata whenua word for man was *hakana*, versus *tangata* in Toi's language and Hawaiian and New Caledonian *kanaka*. The indigenous expression *a kohi mai* meant "come hither" as it did in the Chatham Islands at the time of European arrival. Toi's equivalent is *haere mai*. Indigenous *waihi* meant woman versus *wahini* in Toi's tongue; *kohai rahu?* meant "Who are you?" versus *ko wai koe?*

The linguistic divergence between the languages of the descendants of the first settlers who had arrived in New Zealand by our estimate nearly 3,400 years ago (see Chapter 20) and the language of Toi arriving over 2,000 years later is hardly surprising. The languages of Samoa and Tonga are said to be mutually incomprehensible today, despite the geographical proximity of the islands. Earlier migrants arriving in New Zealand in small numbers over a long span of time and intermarrying with the indigenous tribes would naturally have adopted local language variants. The linguistic divergence by the time of Toi was probably far greater than that noted at the time of Maui, a thousand years earlier than Toi. And yet, only perhaps a century after the arrival of Toi and his men, in the time of Hoaki and Taukata, there appears to be no recorded problems of mutual language incomprehensibility between North Islanders and visitors from Eastern Polynesia, arriving like Toi in the Bay of Plenty. The explanation for this almost certainly lies in the total control Toi was able to exert over the tribes in the area through alliance and conquest. The imposition of their language on the subjugated peoples by Toi and his men seems likely.

On the subject of significant language divergence within New Zealand, Herries Beattie has written an enlightening chapter in his book *Our Southernmost Maoris*[23]. Beattie argues that the European confining of the Maori alphabet to 14 letters was a "cramping curtailment" (p. 86) which masked the existence of numerous dialects. Beattie argues that 22 of the 26 letters of the alphabet (the exceptions being q, x, y and z) were needed to accurately record the language of the Southern Maori. He tells the illustrative story of an early interview with Kaiporohu, "an official interpreter on Stewart Island":

> He gave me the name for an island which I wrote down as Fallafalla. That did not seem correct so I tried it as Falafala and remarked, 'That looks like Samoan.' He said: 'That is how you pronounce it, but you spell it Wharawhara.' I remarked there was no 'l' in the Maori language, and he replied: "When I was a boy Stewart Island was called Lakiula. Later the people began saying Rakiula, and now they are calling it Rakiura, the same as the Pakeha" (p. 87).

Beattie gives many examples of what he described as "oscillating consonants":

> The early settlers found that Ruapuke was usually pronounced Ruabuke, and Puketapu was sometimes spelt the way it was pronounced, Booketap. The word korari was pronounced koladi in some places and koradi, and I never heard it given as korari except by young Maori trying to emulate the dictionary.

He noted that " the word whanga can be written wanga, hanga, anga, whaka, waka, haka or aka without changing its meaning. Take the common word whare (house). This was usually pronounced "warrie" in Otago, but at Moeraki it became fale (pronounced like our word "folly"" (p. 88).

Beattie also gives examples of what he describes as "movable vowels": "At one place in Otago I was told a wooden utensil was an ipu, at another place it was an opu, and at still another it was upu" (p. 89). He comments too on striking similarities between the language as spoken by the Katimamoe tribe of the South Island and the speech of the Chatham Islands, with "the consonant t , for example, pronounced as "chee" in both, "a" occasionally broadened into "au" and "w" used for "u" in beginning words, and "h" or "w" dropped out of certain words" (p. 90). The well-recognized southern use of "k" where North Islanders use "ng" is also mentioned, so that, for example, "hanga" becomes "haka" in the south.

The preservation of older forms of language and pronunciation in the more isolated parts of New Zealand and especially in the South Island, which was less affected by medieval migrations from Eastern Polynesia, reflects the varying migration histories of the North and South Islands and the complex older history of the indigenous peoples of the South Island. The preservation of the "l" which was retained in Samoa and Hawaii is interesting, for certainly Samoa and most probably Hawaii were first settled, like New Zealand, before 1000 BC. The "l" became "r" in Eastern Polynesia.

16.10 Evidence for an Early First Settlement from Technological Impoverishment and Divergence

The 1,500 years between a Lapita first settlement and Maui's visit would not only be adequate to account for linguistic divergence, but also be long enough to bring about the technological impoverishment of the descendants of first Lapita colonists in New Zealand that aroused Maui's anger. Technologies are rapidly lost when their usefulness declines and they become irrelevant in new conditions. For example, the Chatham Islanders lost the art of cloth-making when they adopted sealskins for clothing. Lapita-age colonists in New Zealand would have had to assume a settled hunter/gatherer mode of existence early in their history, given the sudden descent, 400 years after first settlement, of the coldest period in 6,000 years. The Japanese taro, pre-adapted to higher latitudes, seems to have survived the cold but it is unlikely that any tropical plants they may have brought with them would have survived. Because so few traditional foods could be translocated to New Zealand, Lapita colonists would have been unable to rely on an agricultural base as tropical island colonists could. Their hunter/gatherer way of life might well have seemed primitive to Maui, the New Zealand settlers little better than "wild men of the woods".

A second similarity in the account of Toi's and Maui's visits lies in the claims by Toi's descendants that the indigenous peoples he encountered were technologically backward and culturally inferior. Again the perceived divergences in cultural practices and prerogatives in New Zealand mark a long previous history for the indigenous tribes of New Zealand and a long isolation cutting them off from cultural and technological developments that had occurred in tropical Polynesia.

Yet, as a counter to the recorded view of Toi and his men about the cultural and racial inferiority of the indigenous peoples, it is noteworthy that one of the first moves of Toi was to build a pa, Kapu-te-rangi, in imitation of the indigenous defensive structures. This step was militarily vital given the small number of the newly arrived immigrants who had moved into an already well-populated land. Pa existed in Vitu Levu in Fiji and a few stone-walled defensive structures have been found in Rapa, but they are said to have been unknown in Eastern Polynesia at the time of Toi.

Not only did Toi adopt the local practice of building a pa, but he immediately adopted some of the local weapons used for attacking and defending pa. Elsdon Best comments:

> It is distinctly stated in Maori tradition that the *huata*, the *hoeroa*, and the *kurutai* were Maruiwi [indigenous] weapons, and that they were adopted by the Maori. The first of these is a very long spear, in some cases 20 ft. in length, pointed at one end and having a knob at the other. It was used principally in defending and attacking fortified places. The *hoeroa*is the curiously curved weapon made from whale's bone that is said to have been sometimes thrown at an adversary and recovered by means of a cord. It is also known as a *tatu paraoa* and *paraoa-roa*. The *kurutai* is a short striking-weapon of stone, in form something like a *wahaika*, and of which specimens are seen in the Dominion Museum. These weapons appear to have been found at the Chatham Islands, and some are reported from the South Island. . .Maruiwi are also said to have used throwing-spears, a form of fighting-implement

> but little favoured by the Maori; as also the *whiuwhiu*, or spear thrown with a whip. The latter weapon was adopted and used by the Maori but not to a great extent. It was used principally in an attack on and defence of fortified places [24].

Best also considered the bow and arrow were "employed by the aborigines of New Zealand" [25] and mentions a bow in the Dominion Museum that "closely resembles those from the New Hebrides". Again, as for the pa, this suggests an ancient origin for the bow and arrow in their Spice Island homeland region.

Just as the daring of Maui the Navigator is celebrated in tradition, the shrewd and successful military leadership of Toi is highlighted in traditional accounts of his carefully staged rise to a position of power in the North Island. In his building of a pa and his adoption of relevant local weapons we see the characteristic Polynesian adaptability and quickness to take advantage of new possibilities. Toi's campaign to take control of the Bay of Plenty was indeed effective. Best recounts the stages: the capturing of local men and women to swell his numbers, their acceptance of his leadership and their agreeing to persuade others of their tribe, the Wahine-iti, to join Toi in his pa. As evidence of the indigenous importance of women, two of the four advocates sent to their tribe were "of some rank and somewhat elderly" women. They brought back a hundred men and "upwards of a hundred women" to join Toi [26]. And the single women of the tribe were given to Toi and his 40 men. When 5 men of the Wahine-iti tribe were slain by old enemies of the Pananehu tribe, Toi sent off a group of 50 men to avenge the slayings, with the order that some be spared and brought back to Toi. Twenty-one of these he integrated into his expanding tribe. When another party of Pananehu came to exact revenge all but two were slain and the two captives were persuaded to go and fetch the remainder of their tribe to join Toi. All the principal women of the Pananehu tribe "were taken to wife by Toi and his family group, and the forty men of his party" (p. 207). The practice of migrants intermarrying with the indigenous women to ensure land rights in New Zealand is seen here. For, as we have noted, land rights amongst the tangata whenua, as in ancient Lapita practice and early Polynesian practice, were transferred through matrilineal descent. The practice was adopted by Toi and his men as it had been by earlier immigrants. The same practice continued amongst medieval migrants from Eastern Polynesia for up till five to ten generations after the *Heke*, by which time the *Heke* descendants had the numbers to take land by force [27]. In due course the Wahine-iti and Pananehu came to be called Ngati Awa. Toi's tribes expanded into other parts of the North Island: Tauranga, Hauraki, Tamaki, Hokianga and Taranaki. Tradition speaks of the *Tini o Toi*, the multitude of Toi, as swarming like ants.

16.11 Maori Affiliations with Western Polynesia

One technological affiliation between New Zealand and Western Polynesia, not studied by Burrows [28], is the building of pa. As noted earlier, many constructional elements of the Maori pa can be directly sourced to the Spice Island region, to Borneo and New Guinea so that it is perhaps not surprising to find pa in the Lapita colonies of Fiji, Samoa and Tonga as well as in New Zealand [29]. Indeed, Elsdon Best finds evidence of pa in other Lapita colonies: in Micronesia (at Ponape, Caroline Group), in the Solomons, at Taumako near Santa Cruz and in New Caledonia (pp. 430–434) as well as in Hawaii and the Marquesas. This suggests a possible early Lapita-age provenance for the building of New Zealand pa. It is perhaps not surprising, then, to find a cultural correspondence between New Zealand and Fiji in their use of human sacrifice to give strength to a building. Best quotes an account by a European who witnessed the sacrifice of men in Fiji buried alive to give strength to the post holes of a chief's house (pp. 144–145). In New Zealand there is archaeological evidence for the same practice being used to strengthen the posts of the palisade of the Tawhitirahi pa at Opotiki, a pa Best believed to have been of "great antiquity". He describes the pa becoming "the property of a gentleman who proceeded to level the ramparts; along the line post holes were found, time had removed the wood, but in each hole there was a human skeleton" (pp. 142–143). Best sees the practice of human sacrifice to give strength to a fort as having a wide distribution, occurring also in ancient forts in France, Ireland, Northumberland, India and Columbia. But the practice at Opotiki and in Fiji may well have their roots in remembered practices from the Spice Island region from Lapita times.

16.12 Evidence of a Vestigial Clay Tradition in New Zealand

Pottery is primarily associated with an agricultural mode of life, with the storage and preservation of crop foods, and the trading of agricultural goods. Irrelevant in a non-agricultural isolated New Zealand, the pottery-making skills of their Lapita ancestors would have been quickly lost. The chance of Lapita pots ever being found in New Zealand is therefore infinitesimal. However, a recent article by Colleen Urlich shows that, although Maori did not have a ceramic tradition, they did retain knowledge of clay-firing techniques used in the production from iron-rich clays of *kokowai*. Baked clay balls were ground and mixed with oil "to form a very durable paint, used for application to canoes, carvings, ritually prepared bones of the dead and to paint the superior house rafters in the well-known scrolling patterns of kowhaiwhai" [30]. Urlich comments that "The preparation and use of kokowai, associated as it is with concepts of the blood shed by the Primal Parents as they were ripped apart by their son Tane, was an act that signified tapu or specialness." Urlich points out, however, that

> the whole question of a prehistoric lack of clay knowledge by Maori, let alone a practice of working with and firing clay, has been called into question by the work of Louise Furey. Furey's excavations in Auckland in 1989, just prior to a gas pipeline being installed, resulted in the recovery of several engraved, finely worked and fired clay objects of indeterminate use and small, plain and engraved, fired clay balls. . .These recoveries – some of which were not formed from local Auckland clays but possibly from clay from the Waikato region – combined with the evidence of clay-lined fire pits inside dwellings, and possible fired clay sanitation pits. . .[indicated] that some Maori worked and

fired clay for purposes other than the preparation of paint, at least until the early 1700's (Prickett 1992) according to dating obtained by Furey.

Urlich adds

That Maori should retain knowledge associated with clay while not possessing a ceramic tradition, coupled with the clay concepts inherent in the word kokowai, gives a tantalising hint that clay may have been part of important ritual in the far distant past, long before Maori reached New Zealand. The Creation Myth may be one example of the way in which original Lapita clay concepts were passed to succeeding generations of Lapita descendants. Maori Mythic structure has a genealogy that includes clay, a deity of clay, symbolic actions associated with clay, words for clay and clay usage. Coupled with what we now know to have been at least a sporadic use of fired clay, this might quite possibly be ancient remnants of knowledge connected back to ancient Lapita clay traditions (p. 390).

16.13 Indirect and Consilient Evidence

Although there may be no artefactual evidence supporting accounts of Maui the Navigator's visit to New Zealand, there is a considerable body of indirect and consilient evidence corroborating these accounts. Following the East Australian Current as our paradigm predicts would draw a canoe to a landing on the west coast of the South Island, where tradition tells us Maui landed. There, not unexpectedly, in the foothills beyond the bay, Maui saw the fires of people he assumed to be "wild men of the woods", descendants of first-wave colonists who, by our reckoning, had arrived in New Zealand nearly 1,500 years before. Maui's unexpected discovery of the North Island can be read as evidence of a very long isolation in New Zealand for the descendants of the first-wave colonists since no word of the existence of the North Island had reached Maui's homeland. The linguistic and technological divergence recorded in these traditional accounts supports this interpretation, which in turn accords with the global climate patterns responsible for this long isolation. Maui's encountering a matrilineal society in New Zealand accords with evidence for early matrilineal and matrilocal social structures in the Pacific and with the persistence in New Zealand till long after the *Heke* of the transference of land rights through matrilineal descent. Maui's perception of the people of Orokoroko as *moho* or primitive suggests the obvious difference between the horticulturally based societies of the Spice Islands and tropical Polynesia and the settled hunter/gatherer mode of life that for the first 2,600 years after first settlement was the only one possible in New Zealand. In the light of the historical implications of these traditional accounts of Maui's visit to New Zealand, the one piece of archaeological evidence we do have – the discovery of a Lapita rat haplotype in Palliser Bay – can no longer be deemed anomalous.

The assumption that the absence of archaeological evidence for very early settlement in New Zealand is proof that no early indigenous history existed is, of course, a reworking of the old confusion that the absence of evidence is evidence of absence. It relies too on the limiting assumption that only archaeological evidence can be considered valid.

16.14 From Myth to Prehistory

The integration of the historical and mythological in the tales of Maui the Navigator owes much to the suggestiveness and metaphorical power of the Maori language. It also depends on a world view which finds richness and power in fusions of different levels of reality at significant moments in tribal history. Such fusions are seen to draw and harness mana from the great deeds of ancestors and from the gods and demigods themselves, whose power and mythical deeds the tribal heroes and ancestors re-enact and re-create.

Reading oral traditions with cultural awareness takes us from myth to prehistory. In traditional histories historical information is not always obvious. It may lie beneath the surface, encoded in myth, metaphor and in the roots of the Maori language itself. The stories nevertheless provide a window on a past whose very existence is denied by late settlement theorists or by those who dismiss all such traditional tales as pure invention. For those who deny a factual basis for tradition, there is no Maui angered by the stupidity of the people he fished up along with the North Island. There is no chieftainess at Orokoroko; there are no dogs barking, no children playing, no men fishing in the bay when Maui arrives. The people of Kui, whom Maui left in the North Island to safeguard his land rights, were not found there 750 years later by Nukutawhiti as tradition claims; the 1,200-year-long sequence of colonizing descendants of Maui cannot exist either. By denying tradition, history is impoverished.

Archaeologists are concerned with material evidence, evidence that can be subjected to scientific analysis. They seek the hard core certainties of science. The kind of evidence to be found in tradition is implicit and subtle. Its insights belong to a different domain. Carefully stratified artefacts can open a window on a past but not with the power and detail of traditional story, which can bring to life personalities dead for 2,000 years. The human focus of traditional history stands in marked contrast to the artefactual focus of archaeology.

The traditional account of Maui's voyage to New Zealand establishes that he travelled by a known ocean road. It is clear that knowledge of the ocean road that Maui followed to New Zealand had been preserved in his homeland over the 1,500 years that lie between his visit and the first settlement of New Zealand by the first-wave colonists of Lapita times.

The preservation of knowledge over long stretches of time – in this case the preservation of knowledge of the current-driven migration route to New Zealand – through cold periods lasting more than half a millennium during which that knowledge could not be used suggests the effectiveness of Polynesian oral tradition. It suggests too a remarkable social and cultural stability, capable of supporting for millennia social systems designed to ensure the passing on of knowledge from adept to apprentice in every area of knowledge. Knowledge and opportunity belong together. Opportunity increases the chances of tribal survival. Without the knowledge of ocean roads passed on systematically and securely, the opportunity for a tribe to migrate safely in a time of crisis or defeat might be lost. At every level, from making fire to obstetrics, from reading winds and swell at sea to knowing how to safely beach a canoe, individual and even tribal survival depends on the secure passing on of knowledge and so on the passing on of the opportunities for survival that knowledge creates.

The dovetailing of the science implicit in these traditional accounts with "myth" illustrates the value of consilient evidence for confirming the authenticity of the history they record. Mahitahi is a landfall to which the East Australian current would have drawn Maui's canoe. The linguistic and technological divergences that science would predict for the long-isolated descendants of the Lapita-age colonists who first settled New Zealand are clearly recorded in tradition. The New Zealand matrilineal and matrilocal social structure obvious from Maui's meeting with a chieftainess at Orokoroko matches the evidence presented in Chapter 10 for early matrilineal and matrilocal social structures in Polynesia. Maui's exploration of the coast of the South Island is recorded in detail through place names still preserved in the South Island. That news of Maui's death was brought back to New Zealand and preserved there supports traditional evidence for later colonizations of New Zealand by Maui's descendants claiming land rights by virtue of their descent from him. The consilience of the evidence is remarkable, both authenticating traditional accounts and establishing them as a rich historical resource.

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Chapter 17
The Mythological Context: Tree Worship and the Evolution of Creation Myths

Abstract The settlement history of the Pacific is reflected in the diffusion of tree worship, of associated rituals and of Creation myths relating to the Cosmogonic Tree. Of central importance is the preservation in the isolation of the Chatham Islands, which lie in the Southern Ocean 870 km east of New Zealand, of a 4,000-year-old version of a totemic Creation myth involving the Cosmogonic Tree. This totemic myth is far older than the Creation myths recorded in Eastern Polynesia which involve a purposeful Creator. We suggest that the ancient Creation myth found in the Chatham Islands and also found vestigially amongst an ancient tribe in New Zealand and the tree worship and rituals associated with it were carried to New Zealand with Lapita-age first settlers. For these myths and rituals echo the tree worship known to have been practised in recognized Lapita colonies in Island Melanesia and Western Polynesia. In these colonies the distribution of the sacred Benjamin fig, the focus there for tree worship, matched the distribution of Lapita pottery. The preservation in the isolated Chatham Islands and in New Zealand of a Lapita-age myth and associated rituals supports the case for a Lapita-age first settlement of New Zealand.

Keywords Moriori · Totemic creation myths · Lapita tree worship · Cosmogonic tree

17.1 Introduction

The support for a Lapita-age first settlement of New Zealand that we offer in this chapter involves what is perhaps the most indirect and implicit evidence that we have gathered. It is nonetheless telling. We argue in this chapter that the settlement history of the Pacific is reflected in the diffusion of tree worship, of associated rituals and of Creation myths relating to the Cosmogonic Tree or Vine. Of central interest is the preservation in the extraordinary isolation of the Chatham Islands of a 4,000-year-old version of a myth involving the Cosmogonic Tree. We suggest that this myth, and tree worship and rituals associated with it, which have their origin in the Spice Islands, may well have been carried to New Zealand with Lapita-age first settlers.

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Tree worship is known to have been practised in Lapita colonies in Island Melanesia and Western Polynesia, the distribution of the sacred Benjamin fig, the focus for tree worship in these colonies, matching the distribution of Lapita pottery [1].

The oral traditions that tell of the coming of the *kumara* (sweet potato) to New Zealand embody concepts whose roots can be traced to the Lapita homeland. The story has two parts. The first describes the voyage of the Tahitian brothers, Hoaki and Taukata, to visit their sister Kanioro in New Zealand. It describes how they introduced the kumara to the indigenous tribe of Te Haapu-one-one, the tribe into which Kanioro had married. The brothers had carried kumara with them in dried form as food for their voyage. The instant enthusiasm of the chief, Tama-ki-Hikurangi, keen to obtain this new food for his tribe, was such that he persuaded Taukata to help him build a canoe and to act as its navigator on a trip to Hawaiki to fetch kumara tubers. The building and naming of the canoe and the listing of its crew belong to this part of the story, which is concerned with physically bringing the kumara to New Zealand.

The second part of the story, of equal or greater importance for Maori, describes how the spirit of the kumara was compelled to stay in New Zealand instead of returning to Hawaiki (the homeland). This part of the story tells how Hoaki remained in New Zealand at his brother's insistence and of Taukata's instruction to the returning chief, upon reaching Hawaiki, that on arriving back in New Zealand he must sacrifice Hoaki and plant his body in the kumara field. His sacrificial death, Taukata explained, was needed to ensure the spiritual acclimatization of the kumara to the new land. Tradition notes that every year thereafter at planting time, Hoaki's skull was carried to the kumara plantation to ensure fertility and to ensure that the kumara's spirit stayed in New Zealand.

The use of human sacrifice to ensure the fertility of the land and the success of crops is as old as agriculture and, worldwide, often at the heart of the religious practices of early agricultural communities. Human sacrifices to ensure fertility were widespread in Eastern Indonesia till quite recent times and often associated with tree worship. The same association of human sacrifice with tree worship occurred in Europe also.

That tree worship should arise in Eastern Indonesia is not surprising given the dependence there on tree foods – coconut, bananas and especially sago and breadfruit. Oppenheimer shows that the diffusion of tree worship from the Spice Islands to Europe followed ancient paths for land migration that are flagged with genetic as well as cultural markers [2].

17.2 The People-Creating Tree or Tree of Life

The ancient totemic Creation myths from the Spice Islands of the people-creating tree, the Tree of Life, can be seen as ancestral to European tree worship. They can also be seen as an origin for worship of the sacred banyan tree in India and of the Benjamin fig in Indonesia and Island Melanesia. Oppenheimer [3] shows the myth of the people-creating tree to be at least 4,000 years old, depicted on Mesopotamian cylinder seals dated to 4,100 BP. In the Spice Islands this myth later evolved. Other totemic elements were added: a snake at the base of the tree, a bird in its branches. These later elements diffused to the Middle East, giving us, for example, the serpent tempting Eve in the Garden of Eden in Genesis. The snake in the Garden of Eden is associated with the Tree of Life, which in Genesis has been transformed into the Tree of Knowledge of Good and Evil. Oppenheimer notes that the later motifs of bird and snake passed also to China where both bird and serpent and tree appear in sophisticated, finely wrought metal sculptures dated to 3,000 BP [4].

There is evidence from the oldest indigenous traditions in New Zealand and in the Chatham Islands that it was the 4,000-year-old form, the myth of the people-creating tree, sourced to the Moluccas, that travelled to New Zealand with the earliest settlers. It is this version of the myth that is preserved in the genealogies of the Urewera tribe of the North Island and preserved also in the myths and rituals of the Moriori of the Chatham Islands. This reinforces the possibility that the homeland of the first New Zealanders was in the Spice Islands where the myth has it origin. It also suggests that the first New Zealanders migrated from the Spice Islands after 4,100 BP, when we have the primitive people-creating tree myth represented on Mesopotamian cylinder seals and before 3,000 BP when the later mythical elements of snake and bird – absent from New Zealand and the Chatham Islands – are represented in Chinese metal sculpture. The chronological margins are appropriate for a Lapita-age first settlement of New Zealand.

Use of the Benjamin tree as a focus for tree worship in Island Melanesia and Western Polynesia and the significant matching of its physical distribution with the distribution of Lapita artefacts emphasize both the Spice Island origin and the Lapita diffusion for the tree worship that is rooted in the totemic myth of the people-creating tree.

Oppenheimer sees Wallacea as possessing the greatest diversity of ancient Creation myths and flood myths. And he sees the Spice Islands as the source for a diffusion of these myths stretching not only to the Middle East but as far into Europe as Germany and Finland, into India and Asia, possibly into Australia and even the Americas, and from Madagascar to Easter Island.

The great diversity of flood myths in the Moluccas is hardly surprising given the catastrophic floods of 11,500 BP and 7,500 BP which drowned Sundaland and parts of Sahul. The great diversity of ancient Creation myths, on the other hand, possibly stems from Sundaland's role over 1.2 million years as a major Ice Age refuge for early hominid species and countless animal and bird species as well as eventually for *Homo sapiens*. The slow aggregation in the Spice Islands over time of creation myths from very different sources may be collectively represented by these myths. For example, the distribution of myths about a hero "snaring the sun" in order to slow it down, attributed in Polynesia to the demi-god Maui, ranges from tribal central Africa to the Inuits of the Canadian Arctic to tribes in central North America [5], suggesting just how ancient the myth might be: possibly tens of thousands of years older than the more locally derived deluge myths.

Totemic myths, possibly the oldest kind of Creation myths, occur commonly in Western Polynesia and Micronesia, though they appear to be absent in Eastern Polynesia. But although totemic elements relating to the Cosmogonic Tree appear to be missing from Eastern Polynesia, Samuel Timoti Robinson [6] in a recent book, *Tohunga, The Revival, Ancient Knowledge for the Modern Era*, suggests that these totemic elements may have been preserved in the Society Islands in connection with the Io religion, full knowledge of which was strictly limited to the highest levels of priests. With its transmission even to ordinary tribal members forbidden under pain of death, knowledge of the Cosmogonic Vine and all it represented may well have been denied to European collectors and so unrecorded in published collections of Eastern Polynesian myths. In contrast, the central place of Creation myths involving the Cosmogonic Tree in tribal traditions in the Chatham Islands, without *tapu* restrictions, suggests its antiquity there and a diffusion path other than one from Eastern Polynesia.

The preservation of this myth in the Chatham Islands accords with the preservation of two genealogies there, also of great antiquity. The Chathams, cold, remote, windswept islands lying 870 km east of Christchurch in the Southern Ocean, have a history of isolation perhaps comparable with that of Easter Island. The Moriori's geographical isolation and their immunity from conquest till their enslavement in historical times appear to have made possible the preservation of ancient mythical and cultural concepts in forms possibly unchanged from Lapita times.

Many of the early myths about people-creating trees in Island Southeast Asia are very simple: a banana tree, for example, creates people from her bananas or a woman uses a banana to impregnate herself and gives birth to a son and daughter who produce offspring and create the human race; or a tribe claims descent from a tree. The Moriori myth of the Cosmogonic Tree is very much more sophisticated than these, though far less developed than Te Arawa myth of the Cosmogonic Vine, which Robinson sources to Eastern Polynesia. The Moriori myth is concerned with the relation between the mortal and immortal worlds. Though rooted in the Earth, the branches of the Cosmogonic Tree reach up through all ten heavens. The Benjamin fig, the focus for tree worship in the Lapita colonies, in the Spice Islands and in Indonesia, has aerial roots which stretch down from the tree branches to the ground where they take root and send up new shoots. The sacred banyan tree of India likewise has aerial roots. Even the Norse World Tree, the huge ash Yggdrasil, harking back to its tropical origins, has three huge aerial roots. This feature suggests a living embodiment of the power of the tree to link heaven and earth, to connect the mortal world of man to the immortal realms of the gods. Because of its linking power, the tree can be the medium through which supernatural power can flow from otherwise inaccessible realms to the earth bringing fertility to people, crops and animals. As the linguist Waruno Mahdi [7] expresses it,

> The paradoxical aerial roots of the benjamin tree, reaching down from the branches instead of being in the ground, apparently marked it as a 'heavenly' tree. These aerial roots reached all the way down, finally to penetrate into the earth, appearing to enact the unification of the upper- and lower-worlds.. . .Furthermore, aerial roots that had reached the ground developed into secondary trunks, in which an eerie dark and moist atmosphere

provided an ideal biotope for many insects and reptiles, supplying ample nourishment to the imagination.

Mahdi comments also that

The sacred benjamin tree cult not only coincides in its distribution area with megalithism at least in Western Austronesia, but actually forms an integral part of some megalithic monuments or ritual meeting places. Colani (1937) noted that a stone terraced construction at Do-link in central Vietnam had a tree of the genus Ficus at its top. A benjamin tree is reported by Roder (1939) at the top of the megalithist hill-sanctuary and meeting place at Soya near Ambon, central Maluku [Moluccas/Spice Islands].

Mahdi describes in detail the place of actual fig trees with aerial roots in association with megalithic objects as ritual mediums in many Lapita colonies. He reports, for example, a ritual dancing ground of a village of the Lambumbu on the island of Malekula, Vanuatu, described by Deacon in 1934 as "a large circle surrounded by upright monoliths and with a tier of four standing stone slabs at the centre. Two avenues lined by pairs of stones lead in opposite directions from the circle. At another point on the perimeter, approximately equidistant to the ends of the avenues, stands what is described as a gigantic banyan tree. The entire circular dancing ground lies within the shadow of the giant tree." Mahdi gives evidence of similar ritual plantings in Malekula, Pentecost, Erromango and Tanna in Island Melanesia where the shade of the tree serves as a meeting place. In New Caledonia the sacred banyan tree is usually found at burial and other hallowed sites. Mahdi tells us that

In the Marquesas islands in Polynesia, tribal or chiefly centres had as a rule a tohua, an elevated terrace on which was a large rectangular gathering field surrounded by smaller stone terraces with houses of the chiefs and priests, temples and other important houses or galleries. At one end usually stood the main temple with a sacred banyan tree before it, in which the bones of particularly revered dead ancestors were hung (Suggs 1982: 779). This Marquesan sacred banyan obviously paralleled the sacred benjamin atop stone terraces or other megalithic complexes in Southeast Asia noted above. The exposure of the revered bones, as also the New Caledonian burial custom, may perhaps be associated with the custom of reburial after excarnation, attested for the megalithism of Southeast Asia and south India. In the Marquesas, the banyan was also one of two tree species regarded as sacred in general, and which were almost always associated with sacred mortuary sites (pp. 201–202).

Where Mahdi sees tree worship originating in Western Austronesia, Oppenheimer sees its origins in the Spice Islands and, as we have noted, traces its diffusion along migration trails (which have left genetic markers) into northern Europe as far as Finland. Mahdi himself tentatively suggests a link between the tree cult associated with the sacred benjamin tree in Indonesia and the sacred linden tree cult among German and Slavic peoples in Central Europe:

It was customary in some regions of Central Europe that a hallowed linden tree stood in the village square or the yard of a castle (not unlike the banyan in Java or the Marquesas), or in a graveyard (cf. the banyan in Kisar or New Caldedonia), or that the shade of an old linden tree served as a permanent place of session of a court of justice (like the meeting place in Tanna).

James Frazer in *The Golden Bough* [8] gives examples of tree worship in countries ranging from the Philippines to Germany, fundamentally associated with the beginnings of horticulture and rituals for ensuring fertility for crops, flocks and people. The mythic and ritualistic parallels between cultures are close enough to suggest diffusion rather than separate evolutions. Human sacrifice to ensure fertility was widely and in places quite recently practised. To quote Frazer,

> In the holy groves of Upsala men and animals were sacrificed by being hanged upon the sacred trees. The human victims dedicated to Odin were regularly put to death by hanging or by a combination of hanging and stabbing, the man being strung up to a tree or a gallows and then wounded with a spear. . .The Bagobos, one of the Philippine Islands, used annually to sacrifice human victims for the good of the crops in a similar way. Early in December, when the constellation Orion appeared at seven o'clock in the evening the people knew that the time had come to clear their fields for sowing and to sacrifice a slave. . .The victim was led to a great tree and his arms stretched high above his head, in the attitude in which ancient artists portrayed Marsyas [a satyr from Phrygia in Greece, similarly sacrificed] hanging on the fatal tree. While he thus hung by his arms, he was slain by a spear thrust through his body at the level of the armpits (p. 354).

Frazer adds, "These sacrifices have been offered by men now living." Oppenheimer (p. 429) notes that Frazer did not miss the repeated analogy of such rituals, associated with the dying and rising Tree god, with the Crucifixion of Christ (hung on the Tree of Life and speared). As evidence of the widespread diffusion of fertility rituals involving human sacrifice associated with tree worship, Oppenheimer gives evidence he himself uncovered in the Nias islands in Indonesia of links between human sacrifice there and human sacrifice in ancient Scandinavia:

> Humans and animals were sacrificed often by hanging from trees to ensure fertility. That humans, often priests of the fertility cult, were hanged we do not have to rely on Roman hearsay for evidence. There are grisly but well-preserved remains found in the peat bogs of northern Europe. Ritually hanged victims had carefully plaited collars or neck rings that served not only to send them to the netherworld but also to admit them on arrival there because these rings symbolised the fertility goddess. I have seen elaborately plaited male neck rings in the Megalithic cultures of the Nias islands in Indonesia. . .although their original function has been forgotten (p. 429).

Frazer demonstrates that tree worship was found in complex and primitive societies alike. He gives an example from Rome: "In the Forum, the busy centre of Roman life, the sacred fig-tree of Romulus was worshipped down to the days of the empire, and the withering of its trunk was enough to spread consternation through the city" (p. 111). He tells us too that

> Sacred groves were common among the ancient Germans, and tree-worship is hardly extinct amongst their descendants at the present day. How serious that worship was in former times may be gathered from the ferocious penalty appointed by the old German laws for such as dared to peel the bark of a standing tree. The culprit's navel was to be cut out and nailed to the part of the tree which he had peeled, and he was to be driven round and round the tree till all his guts were wound about its trunk. The intention of the punishment clearly was to replace the dead bark by a living substitute taken from the culprit; it was a life for a life, the life of a man for the life of a tree (p. 110).

The widespread diffusion of tree worship amongst agricultural peoples across a wide expanse of the globe is based on concern with the fertility of the crops and animals on which they depend to support growing populations. Hunter/gatherer societies preserve a stationary population with population growth rates adequate to replace rather than to expand their numbers. A significant demographic increase in the world population followed the horticultural revolution 10,000–20,000 years ago. The evolution of tree worship often with associated animal and human sacrifice seems to have followed from a recognized need for fertility amongst horticultural societies, made more urgent by reliance on specific crops whose failure could lead to famine.

It is clear that the central element in the Spice Island myth of the Cosmogonic Tree, which underlay tree worship, was perception of the Tree of Life as a creative power, able to act as a bridge between Earth and the heavens and to bring fertility to the earth. In tree worship this fertility was brought through the medium of a sacred tree, representing the Cosmogonic Tree itself. That this form of the myth, which underlies tree worship, was that carried by the Lapita peoples to Island Melanesia and Western Polynesia and to New Zealand is attested by the distribution of the Benjamin fig to Lapita sites. Tree worship, associated with the definition of a sacred place around a sacred banyan (fig) tree and beneath its shade, is evident in the Marquesas also. The discovery of ceramic sherds in the Marquesas, some sourced from their clay to Fiji [9], suggests a possible early direct diffusion of tree worship to the Marquesas from Western Polynesia.

In the European story of Jack and the Beanstalk (a version of the Cosmogonic Vine), Jack is able to use the magic vine to climb into another world where, like the hero in many a folktale, he kills a giant. The Biblical "Jacob's Ladder" likewise links Earth and Heaven. But in the version of the myth of the Cosmogonic Tree that we find in the Chatham Islands, we have the preservation not just of the idea of the Cosmogonic Tree as a link between mortal and immortal worlds but as the Tree of Life, as the Primal Power of Creation.

In most places where tree worship was practised, and human and animal sacrifices carried out, there was a sacred tree which was seen as a living representative of the Cosmogonic Tree and worshipped as that tree. It was believed to be able to ensure the flow of Life from the Tree to the tribe, to its crops and land. Often the tree was believed to be derived from a seed or a cutting from the Tree of Life itself. Roslyn Poignant gives a clear example of this from Micronesia [10]:

> It is said that Nareua picked flowers from the ancestral tree and flung them to the north of Samoa. Where they floated the Gilbertese islands of Tarawa, Beu and Tabuteuea came into being. This charming allusion to the migration of people from Samoa to the Gilbert Islands was supported by the belief that two great trees, which stood on the island of Beru, had grown from pieces of the Ancestral Tree. They were referred to as the male and female ancestors of the main tribe, Karongoa, and were treated with due deference until they were cut down by missionaries in 1892.

The Tree of Life as a totem was seen as a means of drawing life force from the potent magical worlds with which it was in contact to ensure fertility for crops, animals and people on the Earth. Symbolically the Tree of Life was an embodiment of fertility and continuous Creation – a natural symbol in Island Southeast Asia where tree crops are a major food source. As Oppenheimer has shown, sago trees and breadfruit, banana and coconut trees are all associated with Creation myths in the Spice Islands, usually used by an old woman, the Creatrix, in the creation of wives for young men. In time the Creatrix took on some of the power of the Cosmogonic Tree itself which was thought of as fructifying all trees. The same path of evolution in Eastern Polynesia leads to Tane, the god of forests and creator of trees, taking into himself the creative power of the Cosmogonic Tree to separate heaven and earth and bring light into the world, and to create man by breathing life into the clay image he has made. In Eastern Polynesia the totemic myth evolves to one involving a purposeful parentless Creator.

17.3 The Cosmogonic Tree in the Chatham Islands

Ironically the myth of the Cosmogonic Tree was preserved in the Chathams by a people without horticulture. Entirely hunter/gatherers, the Moriori people of the Chatham Islands were not concerned with promoting the fertility of land to raise crops to feed a burgeoning population. Indeed they castrated a proportion of male babies to limit population growth.

For the Moriori the ancient totemic Creation myth of the Cosmogonic Tree is fused with two Creation myths. One, common throughout Polynesia, begins with the violent separation of Heaven and Earth, the tearing apart of Rangi, Sky Father, from Papa, Earth Mother who are locked together in a smothering sexual embrace, so that their children, trapped between them, are confined in darkness. Through the separation of Rangi and Papa by the Sky-Propper, light and space are brought into the world. The second Creation myth recounts the story of the creation of man by the Sky-Propper.

The Moriori version of these myths is unique. The Sky-Propper does not call upon his own power, as we find in most Polynesian versions of Tane as Creator, but on the power of the Cosmogonic Tree, the Tree of Life. He does so first to prop up the sky to give light and space to the Heaven Born (the children of Rangi and Papa) and secondly to empower the creation of the first man. The Sky-Propper is the agent, the Tree of Life is the source of power. There is a suggestion too that the ten props with which the Sky-Propper separates Earth and Sky are not just his tools but also represent and partake of the power of the Tree of Life.

The primacy of the power of the Cosmogonic Tree in the Moriori version of the myth over a male creator suggests the antiquity of this version. It harks back to early matriarchal versions of the myth involving a Creatrix. But it has a male Creator instead of the female Creatrix that we find in still earlier versions in the Spice Islands. The male Creator acts for, and to some extent represents, the Tree of Life. In later Eastern Polynesian versions he effectively replaces the tree.

The stages in the evolution of the later form that was brought to New Zealand by medieval Eastern Polynesian migrants are obvious. In the later form the Sky-Propper has a name as well as a function. As Tane, the divine creator of trees and god of forests, he uses his own power directly to prop up the sky and as "divine potter" to create man from a clay image. Given that the later Creation myth of the "divine potter" evolved from the myth of the Cosmogonic people-creating tree, it is hardly a coincidence that Tane, the Sky-Propper, is the god of forests. In the story of Tane, who is the heaven born son of Rangi and Papa, violently attacking his father to achieve freedom, the hint of the older version of the myth survives in Tane's use of sky props (which it is natural to think of as tree trunks placed one on top of the other). In the myth of the Cosmogonic Tree its trunk and branches are seen as linking the earth, where mortal man lives, to the ten heavens and the realms of immortality, normally out of his reach. In the simplest form of the later Eastern Polynesian version of the myth, available to all members of the tribe, the sky props form a tree trunk not linking but separating the ten heavens from the earth. In the more complex sacred form, restricted to tohungas and their pupils, the Cosmogonic Vine binds the ten heavens together but the ten breaths of Io, the Supreme God, are seen as fundamental to the secure establishment of the heavens.

17.4 The Cosmogonic Tree as the Primal Power of Creation in Moriori Myth

It is clear that tree worship was part of the Lapita cultural complex. If New Zealand was a Lapita-age colony and the Chatham Islands a probably accidental secondary colony from New Zealand, it is not surprising to find, in the earliest indigenous traditions in New Zealand and in the Chatham Islands, belief in the Cosmogonic Tree as the fount of Life, the primal power of Creation. And it is not surprising to find the belief that this power can be tapped by a powerful tohunga (priest, shaman) using *karakia* (incantations, invocations). The Sky-Propper of the Moriori is presented not as the parentless male Creator, the "divine potter" we see in most Eastern Polynesian Creation myths breathing life into an image of man he has made of clay. The Moriori Sky-Propper works magic through invocations used to raise and release the power of the Cosmogonic Tree. He does so in order to perform two great deeds, involving what is seen as the greatest magic of all, the separation of Heaven and Earth and the creation of man.

The Creation myth of the Moriori records the very invocations used to work such magic. The recorded invocations open what we see as a unique and direct window to a Lapita world. In this chapter we quote just the incantation for creating the body of man and the "gathering" of his spirit into "the world of existence". The translation is Alexander Shand's who recorded these myths [11]. His explanatory notes are given in square brackets in the text.

> Then, for the first time there was light, and the world existed. That ended, Rangitokona (the Sky-propper) heaped up earth in Papa and made man – Tu. This was the incantation used:
>
> STEM or BODY HEAPED UP

1. Stem heaped up, heaped, heaped up; stem gathered together, gathered, gathered together; heap it in the stem of the tree, heap it in the foundation of the tree, heap it in the fibrous roots of the tree, heap it in the butt of

the tree; heap it, it grows; heap it, it lives; the heaven lives, e! Stem heaped up, stem heaped up; let the heaven stand which lives.

2. Heap it in the flower of the tree, heap it in the leaf of the tree, heap it in the swaying of the tree, heap it in the waving [Or, extending branches] of the tree, heap it in the pattern of the tree, heap it in the finishing of the tree; heap it, it grows; heap it, it lives; the heaven lives, e! Stem heaped up, stem heaped up, let the heaven stand which lives. [This appears to represent man formed.]

This was the forming of the body of Tu; then the spirit was gathered in.

"THE GATHERING IN."

1. "The spirit of man was gathered into the world of existence (or possession) to the world of light – see, placed in the body the flying bird (the spirit) – whirl (or breathe)!" [Bubbling of the breath like a whirling current]
2. "Sneeze living spirit to the world of existence, to the world of light. See placed in the body the flying bird (or spirit). Live! live! Spirit of Tu; live!" [This is the Tihe, or sneezing, recited by a mother on the birth of her child when it first sneezes, to gather in the spirit. In the case of sick persons, prostrate or apparently dying, when they sneeze, this Tihe is recited.]

Then man lived and the progeny of Tu grew.

The incantation for forming the body of Tu, man, calls on power from every part and aspect of the Cosmogonic Tree. Instead of forming an image of man from red clay, red from the bloody separation of Rangi and Papa, Colleen Urlich tells us [12], the Sky-Propper heaps up soil in every part of the tree. In place of the sacrificial power of the blood of Rangi and Papa empowering creation, it is through the power of invocation that the tree is called on to form the body of Tu (man) directly. Instead of the divine potter breathing life into a clay image, in the Moriori version, again through the power of the tree, man's spirit is commanded to sneeze and in doing so is "gathered into the world of existence".

There is remarkable sophistication and integrity in this fusion of very ancient myths. As we have suggested, the persistence of the Creation myth of the Cosmogonic people-creating tree in the Chatham Islands is probably due to the isolation of the islands, to their very simple migration history, to a Spice Island origin for its people and to a very long history in the Chathams. The survival there of two very long genealogies stretching back to Lapita times was made more likely by the isolation of the Moriori. These genealogies and the chronological information implicit in them will be studied in detail in Chapter 20.

17.5 The Cosmogonic Tree in Moriori Ritual

The pervasive power of the mythical framework embodied in the concept of the Cosmogonic Tree can be seen in its place in Moriori ritual. Two ceremonies in particular, the Tohinga or baptism of a child and ceremonies relating to Tiki, the first-created man, involve karakia that echo those used in the creation of man. The rituals themselves are interesting, and one wonders if they preserve ancient Lapita rites. The Tohinga ceremonies begin with the creation of a sacred place, which has the same name, *tuahu*, as a burial place, but an alternative translation, the planting place, is clearly relevant for the baptism involves not only sprinkling the child with water but also planting a tree in celebration of its birth. Here we quote a small part:

> Dipping his hand into the puwai [a funnel-shaped water vessel made from the inside tender leaves of flax] presented by the tauira [acolyte], and with the water wetting the forehead and face of the child, the tohunga used the words of the tchua [prayer] as follows:
>
> "Oooi, this is the tchua, a tchua from above;
> Behold the heaping up, behold the gathering together, behold the growth of man
> In the world of existence, in the world of light.
> Let the tchua rise, let the tchua develop,
> Let it ascend before, let it ascend within,
> Proceed the world of existence, proceed the world of light, proceed the intent.
> Behold the tchua pervades, behold the oldest tchua coming hither,
> 'Tis the tchua of the water."
>
> . . .These ceremonies being completed, the next one used was the tira, or tira-koko, which was the name given to the incantation used upon the planting of a tree, symbolising the growth of the child. . .The following is the incantation called tira-koko, the meaning of which appears to be, a tree or sprig planted and . . . dedicated to Tane-Matahu.
>
> "Let the growth increase of the tree on the shore (or land),
> Let the growth increase of the household on shore,
> Let the growth increase of the roots on shore,,
> Let the growth increase of the tree on the shore. It is shaken,
> Shake it in the base and the dark stem, that it may shoot forth,
> See the kawa springs and shoots forth,
> Beat down, close over, let it spring up, shake (open) the soil "
> (pp. 169–171).

Other rituals follow, although Shand did not obtain their details. Implicit in those above is the tohunga's calling upon the power of the Tree of Life to ensure the growth of the child and of the household into which it is born.

Shand's descriptions and comments on the Tiki ceremonies are worth quoting here, especially given his suggestions of the preservation of the myth of the Cosmogonic Tree by tribes in New Zealand:

> In the ceremonies relating to Tiki (the first-created man), of which only a very fragmentary account was given by the old men, there appears to be a close resemblance to that of the tohinga [baptism ceremony], if it was not really a variation of the same ceremony. Neatly carved figures of birds were made out of akeake wood, twenty or more in number, and these were placed in parallel rows on the tuahu [sacred space], which was generally the place where the same kind of ceremonies had been performed before. . ..
>
> There evidently were some ancient stories and ceremonies relative to Tiki, common to Maori and Moriori, the knowledge of which has been lost with the old men of the last generation; traces of this are to be seen in the old karakias and waiatas preserved in Sir G. Grey's *Moteatea and Hakirara*, in the allusions to Tiki, as "Tiki heaped up," "Tiki

gathered together," "Tiki with hands formed," "Tiki with feet formed," and "Tiki the ancient lord" (ariki), or more possibly in its primal sense, first-born, man-created. These references appear to show that they were part of an old Creation legend (p. 173).

There are clear echoes in the Moriori ceremonies for Tiki, celebrating the birth of the first man, of the myth of Creation through the gathering and heaping up of earth in the Cosmogonic Tree and of the Tree's role in the creation of man. Both the tohinga, or baptismal ceremony, and the Tiki ceremonies are re-enactments of Creation and celebrations of the role and power of the tree.

The genealogy for the Urewera tribe that appears in Tregear's *Maori-Polynesian Comparative Dictionary* [13] begins with a list of stages in the creation of man. We quote the relevant names in sequence, with a translation in brackets based on Tregear's dictionary:

Te Ahunga – the heaping together of earth (to form the body of man)
Tiki-Matou – literally "to know man" (symbolizing the creation of man)
I-te pue – (heaping of the earth) in the root (of the tree)
I-te more – (heaping of the earth) in the tap-root
Te weu – (heaping of the earth) in the fibrous roots
Te Aka – (heaping of the earth) in the long thin roots
I-tamatua – in the quickening
I-takitaki – in the bringing onward
Tanumanga – the planting
Tipuranga – the growth
Pukaiahu – the heap gathered together (man's body formed)

The similarity of this account of the stages in the creation of man with those described in the Moriori Creation myth involving the Cosmogonic Tree is obvious. That both the Urewera genealogy and the Moriori rituals have Lapita-age roots is suggested by the evidence for the diffusion of tree worship associated with the totemic myth of the Cosmogonic Tree to New Zealand as well as to Lapita colonies in Island Melanesia and Western Polynesia. The Spice Island myth and tree worship seem to have survived in an archaic form in the Chatham Islands and in a vestigial form amongst at least one indigenous tribe in New Zealand. We suggest that the archaic form may be close to that held by the Lapita-age migrants to New Zealand.

17.6 The Te Arawa Myth of the Cosmogonic Vine

The later form of the cosmogonic myth, that of the Cosmogonic Vine as described by Samuel Timoti Robinson in his book *Tohunga, The Revival. Ancient Knowledge for the Modern Era* [6], is far more complex. It is deeply bound into the esoteric Io religion.

There is a long practice worldwide of using myth and story to encode and preserve vital information. A recent study has shown, for example, how navigational and astronomical knowledge are encoded in Homer's Odyssey [14]. Jeff Evans [15] quotes examples from the Caroline Islands where navigational information is passed between navigators and generations in simple stories known as *aruruwow*. He quotes an example from Arthur Grimble's *Migration Myth and Magic from the Gilbert Islands* in which the hero has just begun a journey:

> when he comes across an old woman sitting in the door of her house (a figurative description of the star cluster Pleiades), on whom he played some familiar trick which causes her to flee westwards (towards the setting sun). Later he meets a man sailing his canoe from the east (similar to the cross section of a canoe, this refers to the V-shape in the constellation Taurus, featuring the star Aldebaran. The two talk until the old woman falls into the sea (Pleiades sets), making such a hideous noise as she disappears, that the hero runs away to the east and takes refuge with two old lepers (the sailing course changes to head towards Gemini).

Robinson's study of the Cosmogonic Vine myth shows how an account of the creation of the world was used by Te Arawa, a significant tribal group from Eastern Polynesia who arrived with the last migration fleet to New Zealand in about AD 1400 (see Chapter 18). They used the myth to encode complex beliefs for tohunga (priests) about the acquisition and practice of spiritual power. The Creation of the world is perceived as a cosmic evolution, moving from ages of *po*, darkness (corresponding to states of ignorance in man), to ages of light (corresponding to states involving spiritual knowledge, awareness and power). What, at the literal level traces the cosmogonic sequence in the evolution of the world, is for the trained adept an encoded guide to the development of personal spiritual knowledge and power.

There is a huge leap in cultural evolution from the tribal story of people being created from bananas to the complexity of traditional knowledge which Robinson reveals. Encoded in details of the evolution of the world is what virtually amounts to an esoteric philosophical treatise woven around the Cosmogonic Vine.

The Moriori versions of the separation of Heaven and Earth and of the creation of man, we have argued, embody the essential concept of the Cosmogonic Tree as the link between worlds – a link that, through the power of karakia, can be used to bring the spiritual power and creative force manifest in the higher worlds into the lower world in which man lives. The tree's power can enable miracles to be effected: to control nature, to ensure fertility for animals, plants and men, to heal sickness, to calm storms at sea. The Creation stories of the Sky-Propper's separation of Heaven and Earth and of the creation of man provide the generic examples of such power being drawn through karakia calling upon the primal creative power of the Cosmogonic Tree. Implicit is the belief that karakia enable a tohunga too to call power from the higher worlds through the Cosmogonic Tree.

In Te Arawa traditions, Robinson reveals, the concept of the role of the tohunga has evolved: the tree is no longer needed. Like the tree, the tohunga himself can make the link between the lower and higher worlds, mentally and spiritually reach up to the higher worlds to call down their power to effect miracles on Earth. In a much more richly detailed analysis of the processes and stages of Creation, Te Arawa secret traditions encode a practical handbook for a tohunga's mental and spiritual training. The information was *tapu*, sacred, limited to the few who were chosen to become tohungas.

The ancient link between the Cosmogonic Tree and tree worship has been replaced in Te Arawa traditions by a more philosophical perception of the evolution of the universe. The Cosmogonic Vine, empowered by ten breaths of Io, is seen as the power holding the universe together. This philosophical view is integrated with the later Eastern Polynesian form of Creation myth, with Tane in the role of divine Creator. In the esoteric teaching, however, Io is seen as the supreme parentless God, the Self-Born, Eternal God who appeared "before the beginning of time" (p. 19).

As though preserved like an insect in amber, the simpler Moriori myth of the Cosmogonic Tree and the rituals based on this seem far older than their elaborate younger Te Arawa cousin. The Te Arawa version has expanded beyond the Lapita stage, preserved by Moriori, where it provided the mythical basis for tree worship and preserved the notion of the Tree of Life as the most potent force in the universe, whose power could be called upon by a tohunga. Te Arawa evolved myth has become the focus for a philosophical understanding of the Creation and of the nature of the universe with the primacy of Io, "the Superior over all the Heavens" central to that understanding. Tane is a powerful god able to separate Heaven and Earth and to create man from clay and even to facilitate the creation of the Cosmogonic Vine. But at the encoded level of the myth there is the assertion that something akin to Tane's power, an echo of that power, is directly accessible to man. Tane is a model for the tohunga. The tohunga no longer has to call upon the Cosmogonic Tree for power, like the Moriori and perhaps their Lapita ancestors. Like Tane, the later tohunga can wield power of his own. This power was built on traditional knowledge and intense practical training, granted only to the few. Te Arawa migrants believed that this knowledge, encoded in myths associated with the Cosmic Vine, once mastered, empowered tohunga to exercise practical shamanic control. Robinson shows us how the evolution of Creation myths led to a fusion of sophisticated philosophical exegis with practical training in shamanism.

In contrast, the Moriori's geographical and cultural isolation appear to have led to the preservation of the archaic forms of the Lapita Creation myths and a culture based on these. The cultural history and evolution implicit in the comparison of Moriori and Te Arawa Creation myths suggests the oldest indigenous mythologies and traditions of New Zealand and the Chatham Islands could reflect their original Lapita form. Study of two ancient Moriori genealogies in Chapter 20 provides evidence for a settlement of the Chatham Islands from New Zealand about 800 BC. It would seem that the archaic Creation myths and rituals preserved in the Chathams came with the Lapita-age colonists to New Zealand almost 600 years before that, carried directly to New Zealand by Lapita-age colonists nearly three and a half thousand years ago.

We have chosen a specific cultural context – that of tree worship (clearly part of the Lapita cultural complex) and the associated totemic Creation myth of the Cosmogonic Tree or Tree of life which underlie Lapita tree worship, to argue for a direct Spice Island cultural origin for the indigenous myths and rituals in the Chatham Islands. Translocations of the sacred Benjamin fig to the recognized Lapita colonies and the association of these sacred trees with mortuary sites and meeting grounds suggest that tree worship was a significant part of what archaeologists term the Lapita cultural complex. Comparison of Moriori myths with Te Arawa forms, which can be sourced to late Eastern Polynesia, suggests that, in the isolation of the Chatham Islands, a Lapita-age version of the myth of the Cosmogonic Tree and of associated myths and rituals may have been preserved in their original totemic form – a form which may be 4,000 years old and have its source in the Spice Islands.

The evidence for a very early settlement of New Zealand presented in Part II is various: it involves demographic computations based on skeletal evidence and on evidence from field archaeology, evidence from a power law analysis of the rank size distribution of New Zealand pa, evidence from global climate history and the history of morphology in New Zealand and evidence gleaned from traditional histories. We believe that the survival of ancient myths and rituals in the Chatham Islands adds to the consilience of evidence from these many contexts for a direct Lapita-age first settlement of New Zealand from the Spice Islands.

The relative isolation of New Zealand before AD 1200 and the extreme isolation of the Chatham Islands through most of their history contrast starkly with the opportunities for genetic, technological and cultural exchange possible in tropical Polynesia. The Chatham Islands were arguably the most isolated settlement in the Pacific. The preservation there of the ancient totemic Creation myths and associated Tiki and baptism rituals is hardly surprising. Significantly their preservation might be seen as supporting evidence for the antiquity and authenticity of two genealogies found there. In Part III these Moriori genealogies, amongst the oldest surviving genealogies in the Pacific, become the means for computing dates for some of the earliest events in the peopling of the Pacific. Combined with genealogical evidence preserved in Rarotonga, they help us to sketch a robust chronology for prehistoric migration in tropical Polynesia stretching back to about 400 BC. More remarkably, they enable us to determine approximate dates for the first settlement of New Zealand nearly a thousand years before this and for the settlement of the Chatham Islands about 600 years later. We see these as key events in the history of the early exploration and colonization of the Pacific.

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Part III
Sketching a Chronology for the Exploration and Colonization of the Pacific

Chapter 18
Dating the Last Migration to New Zealand

Abstract David Simmons' deconstructionist rejection of the *Heke* as an historical event is challenged. Statistical analysis is used to disprove his claim that the canoes of the *Heke*, the last migration to reach New Zealand, were not contemporaneous. To counter Simmons' further claim that the *Heke* was not an external migration from Tahiti via Rarotonga to New Zealand but represented internal migrations within New Zealand, Rarotongan traditions which highlight the conflict in Tahiti that led to the migration are cited and discussed. Establishing the historicity of the *Heke* is important because it represents a migrational watershed, marking the end of long-distance migration to New Zealand from Eastern Polynesia. Coinciding with the beginning of the Little Ice Age, the *Heke* also marks a demographic watershed for, after the *Heke*, even the richer areas of New Zealand were threatened with starvation and experienced drastic population decline. And the *Heke* marks an archaeological turning point in New Zealand as tribes working horticultural land were driven to building pa to protect their lands and the stored harvests that provided some insurance against famine. Establishing a secure date for the *Heke*, further, provides a pillar for the chronology we sketch for Eastern Polynesian prehistory in Chapter 19.

Keywords Historicity of the *Heke* · Canoe genealogies · Statistical analysis · Rarotongan *Heke* traditions · Dating the *Heke* · Historical evidence

18.1 Introduction

In Part I we present evidence that Spice Island explorers, traders and colonizers, following two major currents flowing out of the West Pacific Warm Pool, reached Madagascar and east Africa to the west, Japan to the north and Hawaii and America to the east. In Part II we argue that explorers and migrants, following a third major current from the West Pacific Warm Pool, reached New Zealand to the south. A consilience of oceanographic, genetic, horticultural, demographic, archaeological and cultural evidence, evidence from Island Southeast Asian history and evidence from Polynesian traditional histories supports the claim for two predicted waves of

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exploration and migration from the Spice Island region separated by the 600-year-long global cold period that began in about 1000 BC.

In Part III, to complement the history of Spice Island-based exploration and migration, we sketch a chronology for the history of later, Eastern Polynesian-based, exploration and migration in the Pacific. Voyaging from a base in Eastern Polynesia depended on exploiting the variable winds and currents of the southern Pacific rather than strong currents flowing out of the West Pacific Warm Pool. Different canoes were used. Exploration techniques and sailing technologies were evolved independently.

Sketching a chronology for Eastern Polynesian migration history requires an understanding of global climate history as it impacted on tropical Polynesia. It also depends in some cases on understanding the circumstances, personalities and events within Eastern Polynesia that triggered specific medieval oceanic migrations.

We have chosen as our focus for this chapter the task of dating the *Heke* (the last migration to reach New Zealand from Eastern Polynesia before the Little Ice Age put an end to long-distance oceanic migration). Relevant events are clearly recorded in Tahitian and Rarotongan tradition. Analysis of these traditions provides us with unique means for dating the last migration.

We have a threefold motivation for choosing the *Heke* as our focus. First the *Heke* represents a migrational watershed, marking the end of prehistoric migration to New Zealand and probably the end of long-distance migration within Eastern Polynesia. Coinciding with the beginning of the Little Ice Age, the *Heke* also marks a demographic watershed for, after the *Heke*, even the richer areas of New Zealand were threatened with starvation and suffered drastic population decline. And the *Heke* marks an archaeological turning point. With the advent of the Little Ice Age, tribes working horticultural land in New Zealand were driven to building and defending pa to protect their lands and the stored harvests that provided some insurance against famine. Being able to date the last migration to New Zealand provides a chronological marker for these three turning points in New Zealand prehistory. It also provides a chronological marker for Eastern Polynesian prehistory.

There is an academic motivation too for attempting to date the last medieval migration to New Zealand. In New Zealand repudiation of the historicity of the *Heke* has led to the dominance of deconstructionist histories in the past 30 years. We feel that this has restricted and impoverished understanding. Our aim throughout this book has been to assert the power of tradition to provide historical insights and historical detail inaccessible by other means and in a few cases to capture the personalities of the important ancestors who helped to shape history. It is partly in defence of neglected traditional histories that we argue a case in this chapter for the historicity of the *Heke*. Through a combination of statistical analysis and evidence implicit in both Maori and Eastern Polynesian *Heke* traditions, we show that the arrival of the last migration fleet to reach New Zealand from Eastern Polynesia can be firmly established as a historical event.

Establishing a secure date for the *Heke* provides a pillar for the chronology we sketch for Polynesian and Eastern Polynesian prehistory in Chapter 19. Establishing this chronology in turn helps us to date the first migration to New Zealand – our focus in Chapter 20.

Once central to the study of Polynesian and Maori prehistory, the study of Pacific genealogies by European scholars has been discredited and effectively abandoned in the past 30 years. This followed the wide acceptance of David Simmons' deconstructionist approach to New Zealand prehistory [1]. Simmons argued that, in New Zealand, traditional histories had been subverted by *pakeha* historians (historians of European descent) who imposed their own myths and created their own distorting syntheses and chronologies from "timeless" tradition.

At the time Simmons' book was published, increased emphasis on the need for a more systematic and scientific approach to archaeology, with a focus on stratigraphy and context, coincided with Simmons' debunking of European attempts to establish a chronology from Maori traditions. For European scholars the study of traditional history became dangerously unsound: both politically incorrect and academically dubious. In Part III, we seek sensible new ways to resume the abandoned attempt to derive a sound chronology from tradition for Maori and Polynesian prehistory by exploring new contexts and new sources of evidence, both scientific and traditional.

18.2 The Historicity of the *Heke*

Arguing for a Lapita-age first settlement of New Zealand flows against the tide of research of the past 50 years. The challenge we set ourselves in Part III of constructing a reliable chronology from Polynesian genealogies flows just as strongly against modern research directions. So much is this the case that the very existence of the *Heke* as an historical event has to be defended before we can attempt to date it. And the possibility of using genealogies to generate a sound chronology has to be justified before we can set about our task.

Using the data inherent in genealogies to create a framing chronology for Maori prehistory tempted Europeans from the outset. New Zealand Maori preserved a remarkable oral history and a large body of associated genealogies which captured the imaginations of many European historians in the 19th century. Many became adept speakers of Maori, spoke extensively with Maori on their traditions and made detailed records. The Auckland Museum and Library, for example, has about 10,000 manuscript pages written in Maori by the British Governor, George Grey, on Maori tradition, only a few percent of which have been published. A number of books were published in the 19th century, perhaps most notably the volumes of John White [2], though as with many such collections of traditional knowledge, proper historiographical assessment of sources was very often lacking. In 1892 the *Journal of the Polynesian Society*, now in its second century, was founded by S. Percy Smith and Edward Tregear.

Smith was largely responsible for crystallizing out of the vast body of tradition collected by Europeans a skeleton chronology for Maori and, more broadly, Polynesian prehistory. His approach to the task of assigning dates to key events was to count generations back through Maori lineages to those events. Multiplying the number of generations back to an event by the mean length of a generation and subtracting the resultant period away from the date when the genealogy was recorded provided a dating estimate for the event.

Smith identified three key events in New Zealand prehistory and proposed dates for them: discovery by the voyager Kupe from the Society Islands about AD 925, a colonization by Toi and Whatonga from Rarotonga about 1150 and a major colonization by the *Heke* (fleet) of seven canoes – *Tainui*, *Te Arawa*, *Mataatua*, *Kurahaupo*, *Tokomaru*, *Aotea* and *Takitimu* – about 1350. The *Heke* is associated with many genealogies. Smith determined it as taking place 21–22 generations before 1900. This figure was an average taken from over 50 genealogical tables which agreed to within four or five generations.

This framework was challenged in 1976 with the publication of David Simmons' *The Great New Zealand Myth* [1]. Simmons contested Smith's focus on the migrations of Kupe and Toi, claiming confusions surrounding the identities of both men. There are arguments against Simmons' conclusions where both Kupe and Toi are concerned and the chronology we develop independently of both Smith and Simmons casts some light on the confusions that Simmons highlights. But the main thrust of his book, and our focus in this chapter, is Simmons' claim that the *Heke* traditions relate to voyages made entirely within New Zealand waters and that these voyages may not even have been contemporaneous.

Simmons' attack on the historicity of the *Heke* was significant because the *Heke* had become central not just to European ways of reading Maori prehistory but also to many Maori perceptions of their own tribal histories. The controversy over the historicity of the *Heke* generated by Simmons' book had a general effect of undermining European and to some extent Maori acceptance of the authenticity and historical value of Maori oral tradition. Simmons' deconstructionist approach led to his debunking the "myth" of the *Heke* as a *pakeha* (European) construct. He saw attempts by the 19th century prehistorian Smith to provide a structure and chronology for Maori prehistory, through correlation of data from genealogies, as inappropriate for a tradition that he claimed was "timeless", that is, totally unconcerned with chronology as perceived by Europeans.

As some measure of the impact of Simmons' book, the modern deconstructionist K. Howe [3], following Simmons, seeks to "de-Smith" Maori prehistory. He claims that genealogies are part of an untidy tangle of oral sources that were selected, tidied up and made fallaciously coherent by 19th century collectors like Smith. Consciously or unconsciously these early prehistorians, it is claimed, imposed their own European constructs on Maori prehistory, the "myth" of the *Heke* being the prime example.

A deconstructionist approach to history, as to literature, can offer new insights. But it can also displace or destroy old insights and inhibit new ones. Pei Te Hurinui Jones and Bruce Biggs [4] argue cogently against Simmons' argument that Maori oral tradition is timeless and that it is therefore inappropriate to relate it to a European timeframe. They uphold Smith's belief in the fundamental integrity of oral traditions as an historical source and negate the deconstructionists' view of oral sources as inherently unreliable – tidied up or recreated to suit the "heroic" fantasies of 19th century European historians or invented for their own purposes by tribal historians:

> Maori tribal histories are not located in some timeless past but are invariably diachronic narratives linked precisely to detailed genealogical lattices defining a chronology that is internally consistent and in conformity with biological constraints. Marriages are between people of overlapping lifespans and offspring are born within the possible fertility spans. All of this consistency, besides covering several centuries, is shared by different tribes and subtribes (in this case of the *Tainui* canoe) that have often fought against each other and, one would think, have had good functional reasons for ending up with differing traditional stories if invention were an option.
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> But this is not the case. From subtribe to subtribe the emphases differ, but the events and personages involved remain the same for several centuries of genealogical time. If this was all invented, when did it happen? It could not have been ten generations ago because events pertaining to seven generations ago are included. If the events are seen as continuous up to say, five generations ago, a further question arises. Why would tribal historians sit round inventing an update of recent history when its events, ever on their lips and burned into their minds by the cultural imperatives of kinship and revenge, were known to all?
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> My own anthropological training disposed me to traditional skepticism. . .Recent years of intense involvement, however, have convinced me, as they have convinced others who have had similar experience, that the great interconnecting body of Maori tradition and genealogy makes an overwhelming, if largely circumstantial case for treating it as historical.

The argument of Pei Te Hurinui Jones and Bruce Biggs is a powerful counter to Simmons' deconstructionist approach. The authenticity of Maori genealogies is tied not just to lines of transmission and to modes of transmission as Simmons argues, but to their primary role in establishing claims to land, status, prestige and inter-tribal bonds. It is not the fact of descent but the "how" of descent that gives traditional genealogies their importance. The "how" of descent records the transmission of mana down through the ages. Chiefly status, warrior status, tohunga status, primogeniture and the merging of mana through intermarriage with other mana-laden lines of descent are obvious factors determining the selectivity of traditional genealogies. The more remarkable an individual's genealogy in terms of the accretion and transmission of mana from powerful ancestors and from significant marriage alliances, the more certainly it will be remembered and transmitted, for the individual's political power and status in the tribe depend on it. Uniqueness, selectivity and authenticity go hand in hand. With powerfully motivated remembrance empowering genealogies, it is hardly surprising that they integrate and underpin other forms of orally transmitted history and tradition. Their authenticity validates their use as a valuable historical resource and empowers the likelihood of establishing a tightly bounded chronology from them.

In this chapter we seek both to demonstrate the fundamental integrity of oral traditions as historical sources and to counter Simmons' deconstructionist claims: first by using statistical methods to establish that there is no significant evidence for Simmons' claim that the canoes of the *Heke* were not contemporaneous and then by using traditional evidence to establish the historicity of the *Heke* itself as the last migration fleet to reach New Zealand from Eastern Polynesia before the Little Ice Age. Finally, using science to illuminate prehistory, in conjunction with El Niño proxy data, we use a solar eclipse recorded in Rarotongan and Maori tradition to actually date the *Heke*.

18.3 Analysing Variation in the Lengths of Canoe Genealogies

In the 19th and early 20th centuries, crude dating was obtained by simply using average lengths of genealogies. Arguments for a more sophisticated approach to chronology were made 60 years ago by Kelly [5] to deal with discrepancies in line lengths. Arguing the importance of studying genealogies in the light of other oral sources, L.G. Kelly pointed out obvious factors distorting their line lengths: “The presence of old chiefs with young women naturally tends to lengthen the line on the female side. On the other hand, when lines descend from an elder and a younger member of a family, that of the latter will usually be found to be shorter.” In 1956–1962 J.B.W. Roberton [6] used the concept of a feasible biological range to test the credibility of certain genealogies. He attempted to chart a chronology through matching parallel lines, placing known contemporaries at the same level on the chart and making distinctions between short and long generations spatially. He assigned a chronology based on biological estimates for maximum and minimum values for the assigned spacings. Roberton’s method was convincing and sophisticated but it was not taken up by others or extended beyond the examples he chose. For other work bearing on these issues see H.G. Fletcher [7], Andrew Sharp [8] and J.F.C. Stokes [9].

In contrast with the concern of prehistorians about the variation in the number of generations occurring in different lines of descent from a given ancestor or from contemporaneous ancestors down to the present, most statisticians would feel uneasy if there were not a certain amount of variation. Not only would they expect statistical variation but they would use it as a source of information and a test of consistency for genealogies rather than thinking of it in terms of nuisance parameters.

Simmons’ repudiation of the *Heke* has been largely responsible for modern historians’ rejection of the historical insights and evidence embedded in *Heke* traditions. In the following pages we apply a rigorous statistical analysis to the data furnished by Simmons and used in his repudiation of the historicity of the *Heke*. The analysis shows that the claim that the canoes of the *Heke* were not contemporaneous must be rejected at the usual 5% level of statistical significance. More precisely, we show at the 5% level that there is no statistically significant evidence of difference between the mean line lengths in the various canoe traditions associated with the *Heke* or between the variances of the distributions of those lengths.

18.4 Basic Data

After discussion of genealogies associated with various canoe traditions, the following summaries of line lengths (in generations) Simmons [10] gives.

1. *Mataatua*: 17, 22,18, 14, 20, 15, 17, 18, 15, 19, 18, 18, 16, 17. The whakapapa were recorded from 1892 to the early 20th century.

2. *Te Arawa*: 17, 18, 15, 16, 16, 18, 19, 16, 18, 17, 20, 14, 13, 13, 15, 16. The data was recorded over the period 1843–1856.
3. *Tainui*: 20, 23, 17, 18, 15 (recorded 1842–1860); 20 (1888), 18 (1883). There is also a figure of 34, which, following Simmons, we treat as spurious.
4. *Aotea*: 16 (1853); 19, 23, 19, 21, 18, 22 (recorded from 1894 to the early 20th century).
5. *Tokomaru*: 20 (1894), 16 (1892).
6. *Kurahaupo*: 19, 15. Data recorded in 1892.

The data provided by Simmons for *Takitimu* is less easily summarized. There are a number of lines descending from Kahungunu and also some from Paoa, the captain of *Horouta*. We need to consider how Kahungunu and Paoa relate to *Takitimu*.

Simmons cites Mitchell [11] in placing Tamatea-arikinui, the Captain of *Takitimu*, three generations before Kahungunu, so the variation in lengths of lines from Kahungunu is not directly comparable with that of lines from individuals on *Takitimu*. This is compounded by some of the Kahungunu lines given by Simmons having portions in common and so not being independent. These issues preclude the Kuhungunu lines being given a simple statistical comparison with those relating to the other canoes.

Simmons (p. 117) also cites Hami Ropiha [12] as stating that *Takitimu* was renamed *Horouta* on account of its speed. However, this renaming is contested vigorously by Mitchell [13]:

> A keen, but unlearned student is apt to be confused nowadays by the modern story that the TAKITIMU and the HOROUTA canoes were the one and the same. It is alleged that TAKITIMU was the original name, but that on a trial trip the canoe travelled so fast that the people exclaimed: "Horouta" meaning "the land swiftly passing", thus giving the canoe her second name. This story is a pure invention. The absurdity of it is clearly shown by the suggestion that a sacred canoe could be renamed merely by a simple observation after it had already been named and launched. The naming of such an important thing as a canoe or house was subject to careful selection and a sacred function as follows: After the work had been completed the tapu of the tools employed in the works had to be taken off by a special ceremony. Then followed the naming and dedicating of the vessel to Tane, the god of the forest. After this followed the chanting of invocations for the protection and preservation of the canoe. Then followed the launching. On reaching the sea, and prior to the final trip, incantations were again chanted by the priest to render the canoe seaworthy. After that, the changing of name was unknown.

Mitchell then presents genealogies showing that *Horouta* preceded *Takitimu* by four generations. The confusion noted is perhaps added to by the suggestion that after remodelling by Ruawharo and his people, *Horouta* was later renamed *Takitimu* (p. 43). In view of the above, we believe it inappropriate to associate Paoa lines with *Takitimu*.

We therefore address only the Simmons' data relating to *Mataatua*, *Te Arawa*, *Tainui*, *Aotea*, *Tokomaru* and *Kurahaupo*. The genealogies may be broadly considered as falling into two groups, those coming down to about 1850 and those coming down to around 1900. We subtract two generations from the lengths of the latter to render them more comparable with the former. This leads to the following standardized data, relating to an 1850 base:

1. *Mataatua*: 15, 20, 16, 12, 18, 13, 15, 16, 13, 17, 16, 16, 14, 15. These whakapapa lengths give mean and standard deviation estimates $x_1 = 15.429$, $\hat{\sigma}_1 = 2.102$.
2. *Te Arawa*: 17, 18, 15, 16, 16, 18, 19, 16, 18, 17, 20, 14, 13, 13, 15, 16. These give $x_2 = 16.313$, $\hat{\sigma}_2 = 2.024$.
3. *Tainui*: 20, 23, 17, 18, 15, 18, 16. These lead to $x_3 = 18.143$, $\hat{\sigma}_3 = 2.673$.
4. *Aotea*: 16, 17, 21, 17, 19, 16, 20. These lead to estimates $x_4 = 18.000$, $\hat{\sigma}_4 = 2.000$.
5. *Tokomaru*: 18, 14. These provide $x_5 = 16.000$, $\hat{\sigma}_5 = 2.828$.
6. *Kurohaupo*: 17, 13. These provide $x_6 = 15.000$, $\hat{\sigma}_6 = 2.828$.

18.5 Statistical Analysis

Standard statistical tests utilizing MINITAB treated the data as samples drawn from six canoe populations. Probability plots of residuals were used to test for normality, with 95% confidence intervals. These displayed no evidence of non-normality so it was appropriate to use Snedecor's F test for equal variances with the different data sets. Again there was no evidence for any differences in the variances.

In view of the above, we are justified in using a standard one-way analysis of variance to examine the null hypothesis H_0 that all canoe population means are equal against the alternate hypothesis H_1 that at least two are different. This gives rise to a p value of 0.058. That is, under the assumption that all six canoe population means are the same, the probability of observing as much or more variation than is displayed in our data is 0.058. Thus, using 95% confidence intervals, there is no statistically significant evidence of difference between the mean lengths for the six canoe genealogies.

Our data has a mean of 16.50 generations with corresponding standard deviation of 2.345 generations. This provides the basis for a preliminary rough dating of the *Heke*. First we note that standard calculation procedures based on generation counts require some refinement. The head of a lineage and often the next generation will have been born before the *Heke*. At the other end of the lineage, an informant in the 19th or early 20th century will have been elderly, typically a grandparent. Thus we have one and a fraction generations overcount at the beginning of a lineage and two and a fraction generations undercount at the end of a lineage. The following formulation allows us to refine our calculations to allow for such corrections.

For a given lineage from the *Heke* down to 1850 (a time t (years) later), the successive birth epochs may be modelled as the events of an equilibrium renewal process (see Cox [14]). The number $N(t)$ of renewal events occurring then has mean $E(N(t)$ given exactly by $E(N(t)) = t/\mu$ where μ (years) represents the mean length of a generation. That is, the time interval prior to 1850 that we wish to determine may be obtained by multiplying the number of renewal events by the average length of a generation. Taking the number of renewal points corresponds to adding one to the 16.50 generations to derive a mean of 17.50 generations. The mean has a standard error of 0.342 generations. This small standard error is a consequence of our having the relatively large number of 48 genealogies.

At 25 years a generation, a figure commonly proposed by prehistorians, this would date the *Heke* to AD 1412 ± 8.6. At the end of this chapter we shall derive from rather different considerations 1403 as the most likely date for the *Heke*. The choice 1403 corresponds to an average generation length of 25.5 years, based on statistical analysis of 48 *Heke* lines. We note that the average generation length for the major Rarotongan line considered in the next chapter is 25.2 years, a figure computed from this single line over a period of more than 1,700 years. It may be relevant that some of the *Heke* migrants had genealogical (and so genetic) links to the main Rarotongan line. The difference in the generation lengths derived from 48 Heke lines and that of the main Rarotongan line is statistically insignificant – strong affirmation not only of the reliability of the main Rarotongan line but also and more generally of the reliability of carefully preserved Polynesian genealogies.

The data from the canoe genealogies also provides information about the relative values of the mean μ and standard deviation σ of the distribution of the length of a single *whakapapa* generation. Renewal theory (see Cox, pp. 46, 58) gives

$$\frac{\text{var}(N(t))}{E(N(t))} \approx \frac{\sigma^2}{\mu^2},$$

so that the coefficient of variation $c^2 = \sigma^2/\mu^2$ of the distribution of length of a generation may be derived as $c^2 \approx 0.31$. For $\mu = 25.5$ years, this provides $\sigma = 14.2$ years.

18.6 Historical Evidence that the Canoes of the *Heke* Were Contemporaneous

Simmons may have had a valid point in claiming that European historians have over-stressed the importance of the *Heke*. Certainly the *Heke* does need to be seen in the wider context of Eastern Polynesian migrations to New Zealand during the Medieval Climatic Optimum. Other fleets preceded it. At least ten canoes, for example, are recorded as carrying the ancestors of the Ngati Ruanui and Nga Rauru tribes to New Zealand in this period, though one, the *Panga-atoru*, was prevented from landing and returned to Hawaiki [15]. The early European historians' focus on the *Heke* is, however, far from surprising. The *Heke* is unusual in that such rich traditions relating to its inception have been preserved in both Rarotonga and New Zealand and because detailed traditions have also been preserved in New Zealand relating to its passage to New Zealand and to the destination and later histories of its migrants.

Having used statistical methods to challenge Simmons' claims that the canoes of the *Heke* were not even contemporaneous, we now turn to traditional histories from Rarotonga, Tahiti and New Zealand to challenge Simmons' claim that the *Heke* was not a migration from Eastern Polynesia to New Zealand but a series of migrations internal to New Zealand. First we need to consider Simmons' claim that the "pakeha myth" of the *Heke* was built on inauthentic traditions.

Polynesian oral traditions in New Zealand and the Pacific were transcribed mainly by Europeans at a time when many of the indigenous populations had virtually been wiped out by climate-driven depopulation before contact and then through infectious diseases following contact with Europeans. Such was the assault on oral transmission through these catastrophes that it prompted Smith and other Europeans to do everything in their power to save the endangered oral traditions and the rich culture dependent on them from extinction [16]. Although Smith has been accused of selecting "only what he thought were authentic traditions" [17], in fact he took great pains to eliminate the possibility of outside influences distorting traditions. There was a wealth of very detailed stories of the *Heke* in Tahiti and Rarotonga together with local genealogies that fitted closely with New Zealand genealogies from the epoch of the *Heke* and further back [18]. (We note that Simmons has given little consideration to Rarotongan and Tahitian traditions.) Smith commented that at first he believed that these Eastern Polynesian traditions might have been learnt from some New Zealand Maori visitor to the region subsequent to European contact. However, he then spoke with Tamarua-Orometua, an old man of Nga-tangiia in Rarotonga who was born prior to European settlement there. Tamarua narrated to Smith detailed *Heke* traditions which mesh with those of New Zealand Maori though 500 years had passed since the canoes of the *Heke* left Eastern Polynesia. Tamarua told Smith that these traditions had been taught to him by his father and grandfather. They in turn had learnt these traditions from their forebears. The retention in Rarotonga and Tahiti of traditional histories detailing the circumstances provoking or motivating the *Heke* is not surprising because they focus on a major ancestor, Uenuku. These stories were, of course, taken to New Zealand by the *Heke* immigrants who were caught up in the narrated events. But the independent persistence of these traditions in Rarotonga over the 500 years from the *Heke* to 1900 makes no sense if the *Heke* was not an external migration from Tahiti via Rarotonga to New Zealand but merely, as Simmons argues, a succession of non-contemporaneous internal migrations within New Zealand.

That at least the *Te Arawa*, *Tainui* and *Aotea* canoes were contemporaneous is obvious from the fact that all three migrating peoples came into conflict with the powerful Tahitian chief Uenuku. With conflict escalating and Uenuku determined not just on revenge but on extermination, the peoples of *Te Arawa*, *Tainui* and *Aotea* saw migration as their only hope for survival. With the same powerful chief threatening the survival of all three groups, it can hardly be claimed that the migrations were not contemporaneous. It is equally unreasonable to claim that the migrations were internal to New Zealand when tradition locates the events provoking migration to Ra'iatea. The trees felled to make the canoes, for example, are sourced to Maungaroa on Taha'a island (which is enclosed within the same coral reef as Ra'iatea). And the migrants, having reached New Zealand, proceeded to name places there after places in their homeland. Leslie Kelly [6], for example, mentions the migrants using the old name for Ra'iatea (Havai'i) for a place at Kawhia, giving the name Motutapu (the peninsula at the north end of Ra'iatea) to an island at the entrance to Waitemata and the name Taurere "which occurs on an island which forms the extremity of a long chain of shoals and islets on the eastern side of Porapora" to a place on the Tawake River in New Zealand.

The recording and preservation of such detail in Maori tradition makes more sense for migrants explaining the circumstances that led to their migration across "the great ocean of Kiwa" to New Zealand than for migrants moving from one place to another within New Zealand. The high profile of Uenuku as Rarotongan and Tahitian ancestor has ensured preservation of the same stories in Rarotonga and the meshing of traditions in New Zealand, Tahiti and Rarotonga.

18.7 Rarotongan *Heke* Traditions

The specific causes of the enmity of Uenuku that drove some of the migrants from Ra'iatea to New Zealand are detailed in the *Te Arawa*, *Aotea* and *Tainui* canoe traditions and the dangerous escalation in conflict that preceded migration also made clear. A good example is the story of the conflict between Turi, captain of the *Aotea* and Uenuku. Turi's son, a little boy called Potiki-roroa, tripped when entering the priest's house bringing first harvest offerings. Uenuku killed him for this breach of *tapu* (sacredness). In retaliation, Turi killed Uenuku's child Hawe-potiki, cooked his heart and sent some of it to Uenuku hidden in a food offering being made by a woman of the tribe. After he had eaten it, Uenuku discovered the terrible insult offered to him. Rongorongo, Turi's wife, overheard Uenuku chanting a song which made it obvious he was preparing to exterminate Turi's people in revenge. Rongorongo persuaded her father to give Turi his canoe so they could flee to New Zealand.

Hoturoa, captain of the *Tainui*, had also come into conflict with Uenuku in a dispute over two cultivations named Tawaruangi and Tawaruararo. Kelly tells us that Hoturoa managed to keep his people clear of actual warfare but found his position so precarious that when he saw Turi of the *Aotea* and Tamatekapua of the *Te Arawa* preparing to migrate, he and his companions decided to join them.

That the *Kuruhaupo* and *Mataatua* were part of the fleet is clear from the tradition that when the *Kuruhaupo* was damaged at Rangitahua (believed to be in the Kermadecs), most of its people were transferred to the *Aotea* and *Mataatua* canoes. The role of a fleet in rescuing members of a foundering canoe was undoubtedly one reason for the persistence of migration fleets from earliest times down to the last migration to New Zealand. To ocean rescue we can add the advantage of locating a target with the canoes of a fleet strung out in an arc, within visual or hailing distance of one another, greatly enhancing their joint chances of sighting land. This advantage was, of course, particularly relevant within Eastern Polynesia where island targets were small. Smith estimates that a fleet of ten canoes spaced 5 miles apart within signalling distance would cover a 50 mile arc [19]. (More accurately they would form a 45 mile arc.) A third advantage was, of course, that simultaneous transportation of a large group of colonists enhanced the chances of the survival of a colony. This applied less to the *Heke* than to earlier migration fleets because the *Heke* migrants from different canoes, and even from the same canoe, dispersed rapidly to different areas in New Zealand upon arrival. Perhaps because the country was known to be significantly populated, intermarriage with indigenous tribes was anticipated.

18.8 Historical Evidence for Migration Fleets

Migration fleets are recorded in Polynesian tradition long before Irapanga's fleet of six canoes reached Hawaii (by our calculation in about AD 460). As we saw in Part I, the earliest migrations recorded in Maori *whare wananga* traditions speak of a fleet of six or seven canoes. That fleets were still being used during the Medieval Climatic Optimum can be shown from traditions describing the medieval migrations led by Kahukura (AD 1230). The 2,000 colonists that Kahukura initially settled would have required a fleet of at least eight and possibly ten double canoes to transport them. Kahukura's fleet and the circumstances of the migration are interesting in their own right. They offer a good illustration for our claim that famine and conflict over land and resources were a prime motivation for migrations within the Pacific as well as to New Zealand during the Medieval Climatic Optimum. We quote from Stephen Savage's brief account [20] of the migrations Kahukura led. The skill in conflict resolution Kahukura demonstrates and the suggested use of migration to create possible future refuges in times of trouble contrast with Uenuku's overwhelming commitment to revenge and his drive to settle disputes inexorably by force:

> Ka'ukura, the name of a celebrated ancestor of the Polynesian race. He was a direct descendant of Atonga (Whatonga), another famous ancestor of the Polynesians, being sixth in line from Atonga. According to tradition, it was during the period of Ka'ukura that a large migration took place from one of the 'Avaikis named Amoa, Savaii, Kuporo, and Vai'i. This migration was caused through constant and acute troubles among the people, and is said to have taken place during the period of the year named Iri-nga-te-rangi, and the actual day the fleet departed was named Otutu-metua, probably the 14th September or October. The total number of people that Ka'ukura took away on this occasion was e varu rau 1600 persons, adults. According to the tradition, the following is the manner in which he placed his people on the islands named:- at Iva-nui, two hundred persons with Maro-kura as their chief; at Iva-rai , 200 persons with their chief Te-ika-moe-ava; at Iva-te-pupenga, 200 persons with their chief Ru. Other islands included with these three named, are Te-kirikiri, Te-Rayam and Naeva-Tipa. Ka'ukura then appointed Teuira-te-ai-po as the head ariki over the three islands named, and when he had completed the necessary ceremonies, he addressed the people telling them to ever remember that they sprang from a common stock and were one people. This was when drum beating ceased, and from this fact, Ka'ukura called these islands Pau-motu, meaning the ceasing of drum beating.

Kahukura's settling of another 1,000 settlers is described, with the appointment of chiefs. Kahukura then returns to 'Avaiki to recruit more colonists:

> On arrival at 'Avaiki, where he had left Naea Ariki and his brothers, he found that a revolt had broken out, the cause being the four brothers of Naea Ariki, named respectively, Tuoteote, Kkarae-mura, Uki and Pana, who had become jealous of their elder brother,

> and desired to be arikis [chiefs] also. This led to the trouble which was at its height when Ka'ukura returned unexpectedly. Ka'ukura managed to establish peace, and appointed each of the brothers as tutaras, a rank which was but little inferior to that of the title of ariki. He then selected three hundred more suitable persons, and departed again on his colonizing voyage. On his way he called again at the islands of Iva-nui, Iva-rai, and Iva-te-pupenga, and selected three hundred more persons to add to those he had but recently obtained at 'Avaiki. He sailed away proceeding to Tonga-reva, then to Rangiatea, where according to tradition, he built a koutu which he named Tapu-tapu-atea. He here landed Tamatoa, a son of Tangaroa with his clans, and proceeded to Taiti-nui, where he landed and took up permanent abode, building an ariki house which he named Au-maru.

Placed in the context of the migration fleet led by Kahukura, the seven canoes of the Last Great Migration can hardly be thought of as anomalous. Tradition provides clear motivation for migration in the unwise challenges of Turi and of Tamatekapua to the formidable Uenuku and his extreme reactions to their challenges. An escalation in risk to the point where survival is threatened, given the unbending character of Uenuku, left migration as the only option. The outcomes of every action in the sequence of events that leads to migration arise directly from the personalities of the individuals involved.

If Turi and Tamatekapua were dealing with a Kahukura rather than an Uenuku, the *Heke* may never have taken place. Psychologically, the *Heke* traditions have authenticity. Statistically we have shown that there is no evidence that the canoes of the *Heke* were not contemporaneous. Historically there is clear evidence from Tahitian and Rarotongan traditions that the *Heke* was a migration to New Zealand from Eastern Polynesia. The detail given in the traditions is grounded in place and time and consistent with climatic evidence and El Niño dating which place the Last Great Migration on the cusp between the end of the Medieval Climatic Optimum and the beginning of the Little Ice Age.

Culturally too there is subtle but sound evidence for the historicity of the *Heke*. In some ways this evidence might be seen as the strongest of all. Elsewhere we have argued, from the role the *Takitimu* played as a sacred canoe, that the *Heke* was conceived of as a fleet. Indeed the name "Heke" means fleet. The role of the *Takitimu* was as a spiritual flagship bringing an ark of spiritual resources to New Zealand and conveying three highly trained tohunga to set up three *whare wananga*, or schools of learning, to train future generations and pass on traditional knowledge to the fleet's descendants. The *Takitimu*, too, was an "ark" of bloodlines. Two representatives from every family of the fleet had a place in the *Takitimu* and shared in the task of protecting and conveying its sacred cargo to New Zealand. The canoe itself was sacred: no food could be cooked on it and no woman had a place aboard. Each canoe of the *Heke* carried its own "gods" aboard. The *Takitimu*'s sacred cargo was of a higher order of sacredness and the importance of the sacred canoe for the future of the *Heke* immigrants in New Zealand clearly defined and prepared for in advance. The cultural primacy given to the *Takitimu* is out of keeping with Simmons' paradigm of separate non-contemporaneous internal migrations but entirely in keeping with the traditional account of the *Heke* as a carefully organized, large-scale migration fleet bringing migrants from Eastern Polynesia to New Zealand.

In Chapters 19 and 20 we sketch a chronology for Maori and Polynesian prehistory from the study of traditional genealogies. We propose to show how, sensibly analysed, the genealogies that underpin Polynesian tradition, and have always been regarded by Maori as the backbone of their traditions, can provide prehistorians with a finely delineated chronology. Our approach is specific and pragmatic. It differs significantly from that of the early historians who established the Polynesian Society, in particular in recognizing the variability of generation lengths and in being partly based on climate data to which they had no access. We seek to establish and exploit the interface between El Niño proxy data (a product of modern climate research) and traditional accounts of long-distance voyaging.

The present chapter has a simple focus: to establish a date for the *Heke*. The importance of this date is signal: it is needed as a secure chronological pillar for our analysis of genealogies in Chapter 19 and ultimately for our dating, in Chapter 20 of the first settlement of New Zealand. Both the first and last prehistoric settlements of New Zealand hold an important place in our chronology for the peopling of the Pacific.

18.9 Dating the Last Great Migration

Traditional history can open a window on the past, powerfully recapture time, place, emotions and actions remote from our experience but made accessible to us through the very pacing, tension and detail of the events being narrated. The personalities of the men ranged in conflict live again in the narration and so are known to every generation hearing their history. For Maori listening to the story of Uenuku's defeat of his enemy, Tawheta, Uenuku is not just a name in a genealogy. His mana is palpable for those listening for his responses, recognizing his motivations, hearing his words and watching his actions, sharing his drive to revenge, rejoicing in the defeat of his enemies. The Nga-i-porou version of the story of Uenuku's defeat of Tawheta is powerfully told. Though it is lengthy, we quote most of it in full because it can provide such a remarkable window on the past and because its clear recording of Uenuku's exploitation of a solar eclipse enables us to date the battle of Uenuku and Tawheta to the day, hour and minute. This dating provides chronological bounds that enable us to securely date the *Heke*. The account does much to explain why the *Heke* immigrants retreated rather than face Uenuku's revenge. Uenuku is revealed to be a powerful strategist, lethally intelligent, undeviating in his determination for revenge, exerting total control as leader over his own men, and manipulating circumstances to exert such control over his enemies that they have no hope of avoiding the extinction he plans for them and inexorably brings about. The Nga-i-porou account is given in John White's *The Ancient History of the Maori*, Volume III [21]:

> Ue-nuku was a very great chief of the olden times. One of his wives was named Taka-rita (fallen spirit). She was the sister of a very great chief named Ta-wheta (writhing in pain), who dwelt in large *pas* of his own called Matiko-tai (rise in the sea) and Po-ranga-hau (winds blowing at night).

I will begin my narrative with the death of Taka-rita, the wife of Uenuku, who was killed by him because of her great offence, she having committed adultery with two men called Tu-mahu-nuku (the warm standing earth) and Tu-mahu-rangi (the warm standing sky). Ue-nuku killed her and them, and cut her open and took her heart out, and broiled it on a sacred fire, which fire was lit at the foot of the carved centre-post of his own big assembly-house, which house was called Te-pokinga-o-te-rangi (the thronging of the sky). Whilst he was cooking the heart he chanted this incantation: [omitted here because of its length].

When he had chanted all his spell he fed his mother's heart to his and her own son Ira (wart or pimple). Hence arose the proverb, "Ira, devourer of the rich soft interior." And this saying has descended to his offspring, to the tribe called Nga-ti-ira (the descendants of Ira).

When the news of the death of Taka-rita reached her brothers they greatly mourned for their sister.

Then Ta-wheta (tumble about), one of the brothers, in regard to the death of his sister, asked, "Why was she killed by Ue-nuku?" The relater of the news said, "Because she had committed adultery with two men." Ta-wheta said, "It is right, perhaps; but his act shall be repaid in future, and he shall be eaten by grubs. Here, near me, are his food-preserves, which will induce his children and people to come this way when the season of fruit comes round. He will be full of trouble in future – at the time he desires the little bit of property that is lying on the ground. The women shall be as a cliff for men to flee over." And so this last part of his words became a proverbial saying, and for a long time Ta-wheta dwelt quietly, brooding over his anger.

Ue-nuku did not think it anything cruel to have murdered his wife, nor did he think of the possible consequences. When one summer had passed he had forgotten all about his cruel act, and he sent his children and people to obtain the fruit and products of his preserves in the districts of Matiko-tai and Po-ranga-hau. A great number went; and when they arrived at the *pa* of Ta-wheta, they being unarmed and not suspecting any evil, Ta-wheta killed them all but one: and from this commenced the deadly feud between Ue-nuku and Ta-wheta.

Four of Ue-nuku's sons were slain on this occasion, who were named Maputu-ki-te-rangi (heap in heaven), Ropa-nui (great slave), Mahina-i-te-ata (moon at dawn of day) and Whiwhinga-i-te-rangi (possessing in the heaven); while the fifth, called Rongo-ua-roa (news of the long rain), hardly escaped with his life. He had been severely wounded, and his skull was hacked and broken, and he left for dead amongst the others slain by the murderers.

When Ta-wheta and his people had killed the party of Ue-nuku, they went back into their own *pa*, that they might partake of food, at which time Rongo-ua-roa came to himself, opened his eyes, looked around, and saw his brothers and all his companions all dead lying around him. He crawled away, and hid himself amongst some bushes close by. While there he heard Ta-wheta and his people vaunting over their deeds, and Ta-wheta added, "To-morrow, early, we will go to see Ue-nuku in his *pa*, and we will deceive and kill him too, that he and his may all die together." When they had eaten their repast and had concluded their talk, they came out and dragged the bodies of the slain into the *pa*, to cut them up preparatory to cooking and eating them.

When it was night Rongo-ua-roa crept out of his hiding-place, and crawled into one of the large canoes, and stowed himself away in the forehold, under the bows, and chanted this incantation to insure his not being discovered:

Tu, overspread the face of the sky,
That I may be hidden.
Let their eyes be dazzled,
And flash waveringly
In looking at the stars,
And at the moon,
And at light.
And he was hidden securely, and laid himself quietly down.

Early on the morrow Ta-wheta and his party were up and acting, and preparing to go and kill Ue-nuku. They quickly put the weapons of war into the canoe, and with vigour paddled away towards the *pa* of Ue-nuku. When they arrived on the beach they dragged the canoe up, and proceeded quickly to the pa, whilst Ue-nuku and his people waved their garments and shouted the welcome of “Come hither, welcome, ye illustrious strangers. My child has gone to the distant horizon to fetch you thence. Welcome”. Ta-wheta and people went into the reception-house and sat down.

The people of Ue-nuku now busied themselves in preparing a plentiful repast for the visitors, as they supposed they had come with good intentions only, and thus intended to make them fully welcome; but they had come to murder and eat Ue-nuku and his tribe.

While the repast was cooking, Ue-nuku rose in the *marae* (open space in front of the reception-house) and said, “Come hither, welcome. Are you indeed Ta-wheta?” Ta-wheta from within the house exclaimed, “Thou thyself, thou thyself;” but Ue-nuku continued, “Welcome hither. Did you come from our children and young people?” To this Ta-wheta again replied, “They are all there, enjoying themselves at the usual games of play – spinning tops, flying kites, making cats’-cradles, darting reeds, and all manner of games.”

When the visitors had first entered the *pa*, Rongo-ua-oa had with great difficulty managed to get out of the canoe, and crawl away and sit down under a bush of *toetoe* (cutting-grass), where he basked in the sun; and, the food for the visitors having been made ready to put into the *umu* (ovens) the female cooks went out of the *pa* to gather some grass, green leaves, sedges, and tops of shrubs, on which to place the food in the ovens when cooking. Some of these females went to the spot where Rongo-ua-roa was lying: they saw him, and heard his faint words, by which he told the tale of what had befallen him, his brothers, and party. These women went back to the *pa*, and called Ue-nuku aside, and said, “O old man! It is all false what Ta-wheta says. They have come with a different design. The whole of our people have been murdered by Ta-wheta and his people. Rongo-ua-rua alone is alive. They have come in deceit, and will kill us.” Ue-nuku asked, “Where is the survivor?” The women said “Oh! There he is, lying down outside on the *toetoe*, with his head all beaten with a club.” He said, “Fetch him; lead him into the *pa*.”

Rongo-ua-roa was brought; but first of all he was led to the *tuahu* (altar where offerings are made to the gods, and incantations are chanted to propitiate the gods), and all the proper sacred ceremonies were performed over him, including the feeding the *atua* (god) with his blood, and lifting up his clotted blood (on a stick before Mua) and this incantation was then chanted for him:

Provoking irascible sinew, strong to kill,
Hither is come the one they sought to murder.
Verily, thy own skilful priests are here -
Thou and I together, indeed, as one.
Thy wound is sacred.
The celebrated first-born priestess
Shall cause the lips of the wounds
To incline inwardly towards each other.
By the evening, lo! thy wound shall become as nothing.
The stone axe that caused it
Was verily as the strong tide rushing on
To the shores, and tearing up the beds of shell-fish.
Striving, provoking sinew, eager after food for baking.
The wounding indeed of the man
Who courageously enraged the god.
Thy internal parts are all opened to view,
Verily, just as the stirring-up of the big fire
Burning in the marae (courtyard) of a pa.
But, lo! thou and I together are as one.

This done, Rongo-ua-roa was taken into the *pa* that he might be shown publicly to Ta-wheta and his party. Ue-nuku with his wounded son, had returned to where he had stood when he was uttering the welcome to his visitors, but keeping Rongo-ua-roa on one side of him, and out of sight of the visitors who were in the big house. Ue-nuku again began to speak to them, and said, "Come hither, come hither. You are indeed Ta-wheta. Yes, you yourself have come at last to see me. You are indeed come hither from our children; but are they living or are they dead?" When Ta-wheta heard these words he bounded out of the house, and said, "And who indeed is that god from the sky who is able to kill our children?" Then it was that Ue-nuku said to Ta-wheta, "Our children are slain by you. Behold, here is the only survivor." At the same time he brought Rongo-ua-roa forward, and made him stand in the open space before the door of the house, so that those within might see him. When the visitors heard the words of Ue-nuku, and saw Rongo-ua-roa, they were seized with fear, and would have fled, or have endeavoured to do so. At this time they could all have been killed by Ue-nuku; but it was owing to his noble disposition that they were not. So he kept them till his people had provided food and the visitors had partaken of it. Addressing them, he said, "Do not fear. Remain quietly. Let the food which has been purposely prepared for you be well and properly cooked and served; then eat it and depart."

When they had partaken of the repast they all rose and left the *pa* in silence, and dragged their canoes into the sea. While doing this the people of Ue-nuku clamoured to fall upon and kill them; but Ue-nuku restrained his people, and harm did not come to the visitors.

When they were leaving the shore Ue-nuku called to Ta-wheta and said, "Depart peaceably, O Ta-wheta! Ere long I also will go thither to our children. You are not a warrior, but an evil-doer." Ta-wheta replied, "By what possible means indeed can you venture to go thither – to the home of the many, of the thousands, and of the (little gods called) Rorora (ant), and the Haku-turi (bow-legs, or those who murmur at their knees)?" Ue-nuku answered, "Go away, depart. Soon I shall go thither. You will not escape me; in future you will be devoured by grasshoppers. Your bravery in battle is slippery. Go away, depart." These were the last words of Ue-nuku to Ta-wheta and his party, and they returned to their own place.

After this Ue-nuku stirred up his people to get the war-canoes ready for use. The topsides of these were newly tied together and caulked, and launched to go to war. Then it was that Whati-ua (run from the rain) rose and spoke against going to war at once, and said, "This is my opinion: first let the kumara and the karaka be ripe; then do you go by sea, but I and my party will at once go by land. We will first engage our enemy, and break off the tips of the branchlets of revenge for our sad loss. To-morrow morning we will start."

As they were leaving the *pa* Ue-nuku called, and said, "Listen, friends. This is my word to you: if you capture Pou-ma-tangatanga (or Pai-mahu-tanga) (loose post), let her live to become a wife for me."

The party, which consisted of seventy men, left on their march, and went inland over hills, and travelled till nightfall, when they halted and slept. They travelled all the following day, and again on their march slept at night. On the third day they came in sight of Rangi-kapiti (narrow pass in heaven), and halted till it was dark. In the night they went stealthily and surrounded the big house – the house where visitors were entertained at that place. The people of that district kept watch by night, but were not strict in such duty. When the war-party got near to the house they were made aware that the god had joined with the people in the house, and Hapopo (pulpy, rotten), the priest, was encouraging the people by questioning the god in regard to the expected war-party, and the listening attacking party overheard the conversation of Hapopo and the god. Hapopo said, "Speak to me, is the war-party at hand? We are here dwelling in great fear, not daring to sleep soundly at night." The god, whose name was Te-kanawa (war-weapon of the senior warrior one that has been an heirloom for ages, old club; dazzle, shine brightly), replied, "No; there is not any war-party near – nothing of the kind. Let us dwell together quietly, even as the ancient ones are, who are far off, away in the sky." These were the words spoken by the god through the medium, whose name was Kahu-rangi (garment of heaven). Hapopo (rotten) again asked, "Tell me, O aged! Is a war-party at hand?" The god replied, "Not a bit of a war-party, O aged man! No fighting whatever, O old chief! Will come hither against you. Rest quietly."

Early, and at break of day, the war-party rushed on the big house on all sides, and great was the slaughter of Ta-wheta's people, but Ta-wheta escaped. Though he was pursued, he got away; whence arose the proverbial saying, "Through flight only was Ta-wheta saved." The priest, Hapopo, they dragged out of the house and killed. As he was being killed, he exclaimed, "Lying and deceiving god, you have escaped, leaving the trouble with Hapopo." These words have ever since been used and handed down as a proverb.

Pai-mahu-tanga (nicely healed, or good warmth) was the only one who was made prisoner and rescued from the slaughter by the warriors of Whati-ua. The slain were cooked in ovens and the warriors fed on them, and some were carried back to the *pa* of Whati-ua.

Thus was fully avenged the death of Ma-putu-ki-te-rangi, Mahina-I-te-rangi, Ropa-nui, Whiwhinga-I-te-rangi, Rongo-ua-roa, Hotu-kura (sob for the red), Inanga-tapu-ki-te-whao (white-coloured greenstone made sacred as a chisel), Rangi-whetu (sky of stars), and their companions by Ta-wheta. Those whose names are here given were all chiefs who fell on that occasion.

When the war-party got back to their home they gave Pai-mahu-tanga, the daughter of Ta-wheta, as a wife for Ue-nuku; and thus ended the first slaughter, which was commanded by Whati-ua-taka-marae (run from the rain and occupant of the courtyard).

Notwithstanding this slaughter, Ue-nuku still thirsted for revenge for his murdered children and people. He again commanded a war-expedition to be made ready and launched, and Ue-nuku ordered that each canoe should be provided with extra stone anchors and long cable-ropes. The expedition set forth.

On this occasion Ue-nuku took with him two celebrated garments of his ancestor Tu-mata-u-enga (god of war of the trembling face), in order to become a defensive armour for him. These garments were called Te-rangi-tuitui (the heaven sewed up) and Te-rangi-kahupapa (the heaven bridged over). These had been taken care of by Ue-nuku, who was lineal descendant of Tu-mata-u-enga.

The war-party started and came to Matiko-tai and Po-ranga-hau – to the *pa* of Ta-wheta. Ue-nuku gave orders that the canoes should cast their anchors a little outside of the waves breaking on the coast, and by paying away the cable let them drift in close to the beach. Ta-wheta and his people, having witnessed this, rushed down to attack them if they landed, and even waded out into the surf. One of the party of Ta-wheta, called Putuua-ki-te-rangi (laid in heaps in heaven) went out so far that he was seized by the people of Ue-nuku and dragged into one of their canoes. Ue-nuku at once ordered the people to pull on the cables of the stone anchors and draw the canoes out to sea, where they killed this first prisoner, cut his chest open, and tore his heart out. They then made a sacred fire by friction, and roasted the heart. When cooked, they covered it and the sacred fire with the two sacred garments which Ue-nuku had brought with him. Then Ue-nuku stood up in the canoe and called on the mist of the summit of the mountain called Tiri-kawa (to repeat over and over again the ceremony of baptism), saying, "Attend, fall down, and encompass; fall down and cover up." And the day became suddenly dark, and stars were seen in the sky. Ue-nuku and his people listened, and Ta-wheta and his people were heard fighting amongst themselves in the darkness and killing each other: curses and groans were heard, and also the hollow-sounding blows on each other's heads from their clubs. Ue-nuku called on the mist, and said, "Clear up," and it became clear bright daylight. The war-party looked from their canoes, and saw that many of Ta-wheta's people were still alive. Again Ue-nuku commanded the mist, saying, "Fall on, cover up," and it became as dark as night, and Ta-wheta's people again began to slay each other with great fury. By-and-by Ue-nuku called again on the mist and said, "The mist of Tiri-kawa, break up, clear up at once;" and again it was clear day.

Ue-nuku, thinking Ta-wheta's people had destroyed each other, pulled the garments off the heart and fire, and, looking at the sea, saw it covered with floating corpses and red with the blood of the many slain.

> Three times did Ue-nuku call on his gods before his foes were destroyed.
>
> Then Ue-nuku and his warriors paddled the canoes to the shore and killed the few survivors who were found on the beach; but Ta-wheta and his immediate followers rallied and came on and attacked Ue-nuku and his people, who fought desperately with them, and Ta-wheta was killed.
>
> The battle on the sea was called "The Day of Two Sunsets," but, on account of the great amount of the blood of man in the sea, it was also named "The Sea of Loathsome Water." And the name given to the last battle on land, in which Ta-wheta was slain, was "The Rising Tide."
>
> The victors cooked human flesh day after day; but they could not cook it all, so it was left and wasted, because it became rotten. These are the battles of Ue-nuku the man-eater, and the murders of his children were fully avenged.
>
> Ue-nuku took Pai-mahu-tanga to wife, and she had a son, who was called Rua-tapu (sacred pit). (pp. 13–23)

The detail in this traditional account of the war between Uenuku and Tawheta is fascinating. There can be no doubt that a total solar eclipse occurred – the visibility of the stars by day is specifically mentioned as is the eerie "sunset" that precedes a total eclipse. Mention of "The Day of Two Sunsets" captures this element for us. Uenuku's triple conjuring up of "fog" may also refer to the intensification of the eerie dusk that precedes and follows a total eclipse, though it is more likely that the triple conjuring is a literary device used to heighten dramatic tension and enhance the impact of Uenuku's sorcery. Magic in legend and folktale is often patterned in threes.

It seems very likely that through priestly training Uenuku recognized the signs of the coming eclipse and set out to play the role of powerful tohunga controlling the sun itself to bring about the defeat of his enemies. In Chapter 19 we quote an instance of a Tahitian priest using a solar eclipse to assert his spiritual and political power by claiming to have restored the sun. Duncan Steel tells us that "Random locations on the Earth's surface are transited by a total solar eclipse track about once per 410 years on average" [22]. The passing on of traditional knowledge of the sequence of events associated with a solar eclipse, given their relative frequency, seems likely. There are several historical accounts of battle-leaders in other countries at other times using an eclipse to strike fear into the hearts of the opposing army. Duncan Steel cites several examples of the use of eclipses. A lunar eclipse was predicted by the Roman tribune Sulpicius Gallus to appear on the eve of the battle of Pydna in the Gulf of Salonika and claimed ahead of time to be a sign of divine favour. The Romans won the battle which was pivotal in the eventual Roman control of Greece (p. 16). In 1504 Christopher Columbus evoked the power of the Christian God to eclipse the moon, threatening the Jamaican natives with famine and disease if they failed to supply his party with food and other supplies. The sight of the moon being swallowed up secured their co-operation (pp. 94–96). In 1806 a native American prophet, Tenkskwatawa, promised that the Great Spirit would demonstrate his approval of his followers by blacking out the noonday sun. The appearance of the predicted eclipse led to a rising of the Shawnee, though this ended in tragedy in the Battle of Tippecanoe in 1811. Historians suggest foreknowledge of the eclipse came from a British almanac.

The most curious element in the Uenuku story is Uenuku's apparent advance awareness of the solar eclipse. We are told that before the war-party set out, "Ue-nuku ordered that each canoe should be provided with extra stone anchors and long cable-ropes." His war strategy, based round the eclipse, seems to have been determined and prepared for in advance. Certainly it is likely that Uenuku could recognize the signs of an imminent solar eclipse and that traditional knowledge might encourage him to exploit his esoteric knowledge to enhance his own image as a tohunga able to control the sun and thereby gain an extraordinary psychological advantage for his own men and over his enemy. There may well have been earlier instances of such manipulations known to Tahitian tradition. Indeed, as we have noted, in the next chapter we give an example involving a Tahitian sorcerer in Hawaii. In all societies good leadership, whether spiritual or secular, involves psychological awareness and good stage management. Military battles, like cricket matches, are won through exploiting psychological advantages. Uenuku's management of his war with Tawheta reveals a master psychologist at work. He feeds his enemy and sends him home with the promise of vengeance and defeat to come. His moral superiority over Tawheta is asserted by his own refusal to breach laws of hospitality and his accusation that Tawheta is "slippery" in battle – a cheater, not a warrior. He sends his enemy home to live with the psychologically undermining threat of impending revenge.

On the day of the battle Uenuku doesn't rush in to attack. He keeps his victims waiting. He comes close enough to shore to seize a sacrificial victim and then retreats. He takes his time in slowly roasting the victim's heart, sacrificing him to Tu, the god of war. Uenuku controls the place, time and pace of battle. The anxiety of Tawheta's men waiting for the attack as the eerie dusk of the eclipse settles over the landscape is easy to imagine, especially, as seems likely, if Tawheta's men can hear Uenuku chanting karakia, calling upon the power of his gods whose favour is already becoming manifest in Uenuku's control of the sun. Having worked up his enemy to a pitch of fear and confusion, focussed on delayed but impending attack, the descent of darkness triggers their belief that the attack has come in a darkness generated by a sorcerer. In total confusion they attack one another while Uenuku's war party sits safely offshore in their canoes. Uenuku's men only move to land when victory is certain and the confused and demoralized enemy ripe for slaughter.

The image Uenuku projects and effects from first to last is of possessing total control.

So dramatic is this story – with a total solar eclipse at its heart – that details of the eclipse were preserved, giving us a rare opportunity to date the battle. This we can do with precision. Whereas the land battle took place in Tahiti, the sea battle took place in Rarotonga, according to Smith's sources, where Tawheta had fled after his escape following the land battle. Astronomical calculations establish that the eclipse took place on 28 August 1383 at 2.58 p.m. and lasted 3 min and 2 seconds (Tony Beresford of the South Australian Astronomical Society, personal communication). This was the only total solar eclipse taking place in Rarotonga over the years 957–1498 inclusive.

Working from this secure chronological marker enables us to establish a date for the *Heke*. The land attack on Tawheta's pa led to the capture of Tawheta's daughter, brought back as a slave wife for Uenuku. She gave birth to a son, Ruatapu, whose war with his father provides the next episode in the history of Uenuku. Ruatapu was the first, possibly the only man to successfully challenge Uenuku's power. It is likely that the events involved in Ruatapu's challenge to his father took place after, rather than before, the *Heke*, because the *Heke* migrants fleeing from Uenuku's decision to exterminate them still regarded Uenuku as invincible. Having drawn his enmity, they believed they would be defeated if they stayed to fight.

In dating the *Heke*, it is important to realize that there is a good reason why it was the last migration fleet to reach New Zealand. The migration occurred at the cusp between the end of the Medieval Climatic Optimum and the beginning of the Little Ice Age, which brought an end to long-distance voyaging to New Zealand. There is some controversy concerning the dating for the Little Ice Age in New Zealand. Lamb suggests that the peak of the Medieval Climatic Optimum in New Zealand may have been as late as AD 1200–1400 [23]. Though the Sporer Minimum (which records a significant reduction in solar activity) is dated in the northern hemisphere 1400–1510, Grant suggests that in New Zealand "the Sporer Minimum is contained within the longer cool interval of 1350 to 1510 AD". He describes this period graphically:

> Temperatures fell to 11.9°C, at least 0.6°C cooler than at present. Winds prevailed from the west and southwest. A paucity of auroral counts, an absence of naked-eye sunspot reports and descriptions of the eclipsed sun with no corona mark this period. There were again probably almost no sunspots, and we may presume a similar dearth of other features of solar activity. In the tropics the Sporer Minimum was the coolest spell for the last 1,800 years (Eddy 1977). Generally, the country became drier, and in Hawke's Bay, the Wairarapa and Marlborough southward to Southland, drought became more severe [24].

Drought in the North Island of New Zealand, caused by an El Niño, is usually matched by drought in Eastern Polynesia, although the South Island is not subject to it. The drought Grant describes, associated with low sunspot activity worldwide, appears to have affected both islands of New Zealand and to be associated with falling temperatures. It is possible that a severe El Niño-driven drought triggered the conflict over land and resources between Uenuku and Hoturoa, the captain of the *Tainui*, that is recorded in tradition as a reason for the migration of his people. In Eastern Polynesia, as we have seen, after about AD 900 El Niño-driven drought and consequent starvation and conflict over land and resources typically led to enforced migration for the starving and defeated. Tradition establishes conflict and fear of defeat as the triggers for the last migration to New Zealand. Additional dating evidence for the timing of the *Heke* can perhaps reasonably be sought from El Niño proxy data.

Searching the El Niño proxy data for likely timings for possible El Niño events that may have caused drought and conflict in Eastern Polynesia, we find that in 1403 there was a level 4 El Niño. This was the strongest El Niño in the 200 years from 1245 to 1449. This seems to be the best candidate for dating the *Heke*. The next best option is a level 3 El Niño in 1408. In 1403, given the time of his conception, the maximum age that Ruatapu could have been is 19. He may have been younger. If the *Heke* took place in 1408, he may have been 24. The isolation of Ruatapu, following his father's public humiliation of him, acting alone in his devastating challenge to his father (sinking a canoe and drowning the first sons of 70 families loyal to Uenuku) suggests a dangerous teenager. The balance of evidence and surmise from a total eclipse, El Niño proxy data and the likely birth date of Ruatapu, suggests 1403 as the most probable date for the *Heke*.

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Chapter 19
Correlation of Significant Voyaging Activity with Rare Extreme Climate Events

Abstract Two climatic factors stand out as relevant to the maritime expansions involved in the later west–east exploration and colonization of the southern Pacific: global warmth for protection against hypothermia and strong El Niño Southern Oscillation (ENSO) events capable of reversing the direction of the trade winds and currents. The major impact of ENSO events in tropical Polynesia during the Medieval Climatic Optimum, however, was more in precipitating than in supporting migrations. In tropical Polynesia after c. AD 900, El Niño events brought in their wake droughts, famine and conflict over land and resources, triggering migrations for the starving and defeated. The pattern of strong to severe El Niños in the two global warm periods covered by the low Nile flood proxy data reflects pulses of exploration and migration within tropical Polynesia. It also reflects the pattern of drought-driven migration from Eastern Polynesia to New Zealand that took place in the Medieval Climatic Optimum. In both periods El Niño low Nile proxy data suggests an associated chronology. We have chosen, as a focus for establishing this chronology, Polynesian genealogies associated with a line of navigators and explorers, some of whose exploits are recorded in tradition and can be linked to and tested against an El Niño-based chronology.

Keywords El Niño-driven migration · Nile proxy data · Extreme climatic events · Drought and famine · Pulses of exploration and migration · Dating migrations · Dating exploration

19.1 Introduction

H.H. Lamb presents a paradigm of worldwide, age-old, climate-driven movements of peoples on the Earth. He speaks, for example, of the impact on human history of the temperatures and moisture regimes of the Post-glacial Climate Optimum (6000–3000 BC) when no insuperable desert barriers prevented the vast dispersal of Indo-Europeans over Europe and southwest Asia and parts of India, possibly from a homeland in the Caucasus region. The vastness of this dispersal, Lamb sees as leading to the separate developments of the European language groups, but

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he claims too that most, and perhaps all, "of the later waves of migration which brought first one and then another of these linguistic groups to dominance in this or that part of Europe and southwest Asia seem from their dates to be related to climate change" [1]. Both macro and micro events, the main thrust of migration and successive expansions, he sees as climate-modulated.

The maritime expansions involved in the later west–east exploration and colonization of the southern Pacific were likewise climate-modulated. Two climatic factors stand out as relevant: global warmth for protection against hypothermia and strong El Niño events capable of reversing the direction of contrary winds and currents. The major impact of El Niños in tropical Polynesia during the Medieval Climatic Optimum, however, was as much in precipitating as in supporting migrations. As we have seen, in tropical Polynesia after c. AD 900, and possibly before where populations were high in relation to resources, El Niños brought in their wake drought, famine and conflict over land and resources, triggering migrations for the starving and defeated. Documenting the pattern of strong to severe El Niño events helps to determine the pulse of migrations in tropical Polynesia and to suggest an associated chronology.

Since Lamb's classic was published in 1972–1977, ENSO (El Niño Southern Oscillation) events have become a major focus for research,largely because of interest generated by significant El Niños in 1972/1973, 1982/1983 and 1997/1998. This has led to an enriched understanding of the interactions of ocean and atmosphere and their controlling effects on weather patterns during an El Niño, not just in the Pacific itself but in the continents round its rim. Droughts in Australia, forest fires in Indonesia, a doubling of the frequency of cyclones in tropical regions are but a few of the climatic consequences of a strong ENSO event.

A brief summary of the oceanic and atmospheric forces driving an El Niño might help to explain its dynamic relevance to oceanic migration. Below we quote from two clear descriptions of aspects directly affecting sailing conditions in the Pacific. The first is given by William Burroughs [2]:

> The tropical Pacific can be regarded as a thin layer roughly 100m thick, of warm light water sitting on top of a much deeper layer of colder denser water. The interface between these two layers is known as the 'thermocline.' High SST's correlate with a deep thermocline and vice versa. As an ENSO warm event develops, the easterly trade winds that normally drive the currents in the equatorial Pacific become exceptionally weak. The sea level in the western Pacific falls and the depth of the thermocline is reduced. . . . Intense eastwards currents between the equator and 10 degrees N carry warm waters away from the western Pacific. Along the western coast of the Americas there is an increase in sea level that propagates polewards in both hemispheres. This motion, which may be associated with cyclone pairs in the atmosphere north and south of the equator. . .reinforces the early flow, propagates an eastward motion or wave. This is called a "Kelvin wave" (named after Lord Kelvin in recognition of his fundamental work in wave dynamics).
>
> The changes in the ocean contain two important pieces of information. First, the observed movement in the ocean is a consequence of the alteration of the winds that normally drive the currents away from South America. This standard pattern produces lower sea levels in the east than in the west. It also means that cold water is drawn in from higher latitudes and also from greater depths. As the wind weakens so does the current. Sea levels rise and warm water spreads back to cover the cold water.

Ross Couper-Johnston [3] describes the process above as a self-perpetuating loop:

> Whatever the trigger, a self-perpetuating loop between the ocean and atmosphere is initiated. In the case of an anomalous burst of westerly winds, the winds prompt a switch in the local current, which moves the warm water pool a little to the east. This causes a further relaxation of the trade winds that allows even more warm water to shift east again. The angle of the thermocline flattens, and less cold water is upwelled in the east. This decreases the difference in sea temperatures between east and west and similarly reduces the pressure gradient. Like a sumo wrestler caught off balance and pushed to the edge of the doyo, the interplay between atmosphere and the ocean can force the warm pool all the way across the equator to the boundary of the eastern Pacific.
>
> At the peak of an El Niño, the broad picture in the Pacific is very different from the norm. The thermocline has flattened out considerably. So the deep, cold water normally close to the surface off South America is up to 30 metres deeper than usual. The sea-levels on both sides of the ocean are comparable. And the pressure difference between east and west has disappeared and, at times, even reversed. This is the flipside of the atmospheric seesaw that Gilbert Walker first noticed when he coined it the Southern Oscillation. Because the pressure difference drives the winds, the trade winds disappear and are replaced by westerlies that can blow nearly all the way to the Americas (pp. 39–40).

Ross Couper-Johnston goes on to describe the processes that lead to the end of the oscillation. These have relevance for prehistoric voyaging in tropical Polynesia, for it was the restoration of normal trade winds and westward-flowing currents that ensured a fast return voyage for tropical Polynesian voyagers who had sailed east taking advantage of reversed currents and winds:

> The changes at the ocean surface are reinforced by two other very important and related processes evolving tens of metres below. The first is the excitation of a series of massive ‘gravity’ or Kelvin waves, which travel eastwards close to the equator several tens of metres below the surface. Their effect is to send ‘packets’ of warm water towards the South American coast, further depressing the thermocline in the east. The second, which is sparked in response to the Kelvin waves, is the generation of a series of another type of subsurface wave, known as a Rossby wave. These have the opposite effect of Kelvin waves, heading westward and pulling the thermocline closer to the surface. . .The signal to stop the physical processes that maintain the El Niño phase begins a new feedback loop, this time in the opposite direction. Easterly trade winds strengthen and warmer water is pushed further west, once more enhancing the pressure differential from east to west which drives stronger trade winds (pp. 40–41).

Because of the risk of hypothermia, oceanic migration in outriggers lying low enough in the water to allow for paddling is inherently more complicated and perilous than land migration and has to be effected quickly. After the Exodus, the Israelites (accompanied, no doubt, by herd animals) are said to have wandered for 40 years in the desert in their migration to the Promised Land. Three or four weeks is probably the very most a migration canoe can afford to be on its ocean road. And the impact of weather conditions at sea is critical. The reason El Niño events hold an important place in climate-modulated exploration and migration in the southern Pacific is that for many months they control both winds and currents in such a way as to optimally support west–east voyages within tropical Polynesia. Such support was vital, not for shorter distances where seasonal westerlies might prove adequate, but for the longer time required for long-distance exploration, trading and migration.

An El Niño in the Pacific is heralded by westerlies. As these become stronger, the normal southeast trade winds below the equator are completely suspended, for reasons that the technical accounts of the oceanic and atmospheric processes above makes clear. And so strong do these westerlies become that the normal east–west flowing South Equatorial Current is not only halted but actually reversed, flowing west to east with the winds. In warm period exploration, return-voyaging in the lower latitudes of the Pacific is always possible because an El Niño is a "contained event", an oscillation. When the cycle underlying the phenomenon is complete, weather patterns will reverse, the trade winds and the west–east currents they support will return, ensuring a fast homeward as well as a fast outward voyage.

Optimal conditions for successive stages of exploration and settlement in the southern Pacific depended on periods of global warmth. By reversing contrary winds and currents, ENSO events played a secondary role in providing a speedy passage and safe return for the long-distance voyages undertaken within tropical Polynesia during global warm periods. During a long-lasting El Niño, cloudless skies would have made it easier to navigate by the stars, strong winds and the faster voyaging these facilitated would have decreased risks of hypothermia, starvation and thirst.

In this chapter we focus on the exploits during the Medieval Climatic Optimum and earlier warm periods of a line of famous Eastern Polynesian navigators. Using two climatic bounds – global warmth and periodic strong ENSO events – in relation to events recorded in oral traditions, we endeavour to sketch a chronology for the history of oceanic migration in the periods covered by low Nile ENSO proxy data.

There are some caveats we should note first. There is difficulty in dating climate periods with any precision because they vary from hemisphere to hemisphere, continent to continent and latitude to latitude. The Medieval Climatic Optimum had begun by AD 900 in some parts of Europe and ended by AD 1300. In New Zealand, by contrast, Lamb claims that it may have peaked between AD 1200 and AD 1400 [4]. We are dealing with worldwide warming and cooling events of considerable magnitude and, usually, duration, moderated in some cases by local factors, such as distance from the equator, warm currents, local precipitation factors and glaciation. Long-term factors, such as variation in the earth's distance from the sun, and short-term factors such as increase in sun-spot activity also have profound effects on climate but these effects are unevenly distributed.

The warm and cold periods that Lamb lists and the time scales he proposes for them give us a broad chronological foundation. For more precise calibration of "windows of opportunity" for long-distance oceanic migration and significant voyaging in the Pacific, however, we have chosen another path: we propose to use ENSO events, occurring within the imprecisely bounded global warm periods, to give more exact datings for major voyages recorded in oral traditions. Advances in climatological research in the past 20 years make this feasible.

19.2 ENSO Low Nile Flood Proxy Data

There have been several approaches to dating El Niño events, perhaps most notable among these, William Quinn's pioneering work in compiling anecdotal evidence of El Niños from written accounts dating back to the Spanish conquest of South America [5]. David Enfield [6] points out that these are limited because they only record local phenomena and do not necessarily reflect the global scale ENSO system. Enfield is equally critical of the use of "surrogate" or "proxy" records from tree rings and ice cores for the opposite reason: because these do not relate directly to El Niño events but to teleconnections, that is, to "very large spatial scale… remote interannual climate perturbations beyond the Pacific region of intense interaction" (p. 95). The value and the limitations of proxy records are bound together. "These 'teleconnections' are one of the primary ways in which El Niño-like fluctuations during historical and prehistorical epochs have been preserved in surrogate records by the biosphere and geological processes" (p. 95). Enfield notes the potential for many of the surrogate records to "provide annual resolution (or better) over periods ranging from several centuries to a millennium or more" (p. 103) but he points to the problem that ENSO episodes have such widely varying characteristics and vary so much from the "canonical pattern" that "the teleconnections that produce surrogate records are not perfectly consistent from one event to another" (p. 103).

The same caveats apply, of course, to radiocarbon dating, for which calibration usually depends on dendrochronology (study of tree rings) which can be independently affected by the many factors determining tree growth. And for radiocarbon dating, as for climate periods, there are differential calibration estimates according to hemisphere.

In 1992 William Quinn sought to extend his investigation back in time by undertaking an historical study of ENSO through analysis of Nile River low flood data from AD 622 to AD 1522 [7]. The continuity and consistency of the data made it a natural choice, as did the fact that summer monsoonal rainfall in the Ethiopian mountains which feeds the rivers that feed the Nile, has a recognized teleconnection to ENSO. To further validate his use of Nile River flood data for studying ENSO in the past, Quinn provided a table for the years 1824–1973 comparing ENSO data, including the dating of east monsoon drought in Australia, deficient Indian summer monsoon and weak Nile flood, as a measure of deficient summer monsoon in the mountains of Ethiopia. Quinn demonstrated a correlation strong enough to suggest that strong ENSO effects will be represented by low monsoonal rains in the Ethiopian mountains and so in deficient Nile floods (though local weather anomalies may reduce or augment the deficiencies). There also seems to be a correlation, sometimes delayed, between the strength of extreme ENSO events and the level of Nile deficiency. A good example is the 1876–1878 extreme El Niño reflected in the most extreme Nile flood deficiency in 54 years, though the other two equally low Nile levels of 1913 and 1972 are correlated with very strong (as opposed to extreme) El Niño events.

The most deficient Nile floods (levels 3, 4, 5, 5+) seem to record strong El Niño events reliably. Occasionally it does, however, seem possible that deficiencies will be augmented or reduced by local weather anomalies. Even with this limitation, the Nile records offer a remarkable means of calculating strong El Niño events (to within a one- or two-year period). For our purposes – to establish a chronology for long-distance oceanic migration during the first millennium AD and in the Medieval Climatic Optimum – they provide a remarkable resource, especially given the difficulties of precisely defining for a specific area or even hemisphere the boundaries between warm and cold climate periods.

Ross Couper-Johnston [8] describes the way in which the Nile flood was measured:

> Each year, careful measurement were taken on the Nilometer, an elaborate, Escher-like four-sided stone well with steps down the sides spiralling around a calibrated column in the centre. Underground conduits allowed the water to enter from the Nile. If the level approached the height considered optimum for the prosperity of the people, the guardian of the Nilometer would swim to the column and anoint it with a concoction of saffron and musk. The next day, *wafa* was declared to the public through singers positioned around the Nilometer, and the guardian dressed in a robe of gold thread would lead a great procession through the crowded streets. A signal was given and the feeder canals would be opened to inundate the fields.

Even Shakespeare, Couper-Johnston shows us (p. 76), was aware of the ancient measuring of the Nile flood:

> . . .they take the flow o' th' Nile
> By certain scales, i' the pyramid; they know
> By th' height, the lowness, or the mean, if dearth
> Or foison follow. The higher Nilus swells,
> The more it promises. As it ebbs, the seedsman
> Upon the slime and ooze scatters his grain
> And shortly comes to harvest. (Anthony and Cleopatra)

Low Nile floods, Couper-Johnston tells us, represent a failure of the monsoon rains over the Ethiopian highlands which "feed the headwaters of the Blue Nile and Atbara River each summer, supplying 95 per cent of the flood's volume" (pp. 77–78). The lower the Nile flood the stronger the El Niño event that caused the deficit. Significantly the 900-year period for which we have ancient Nile flood records covers a major period of exploration and colonization in the Pacific.

19.3 Sketching a Chronology for Long-Distance Voyaging

Our interest in El Niño events in this chapter is specific. Our primary concern is in using the El Niño proxy data of low Nile floods as a chronological marker with annual resolution. From the pattern of deficient Nile floods, we can determine the pattern of El Niño events and so, given our proposal of a relationship between El Niño events and enhanced maritime possibilities, seek to determine the pulses of long-distance migration and of significant voyaging activity in the Pacific in the two global warm periods covered by the Nile flood proxy data. Because El Niños caused long-lasting reversals of the trade winds and currents, they provided insurance for long-distance return voyages. If an El Niño supported a journey to the east, with its cessation the restored winds and currents would carry the voyager home. If a journey to the west was undertaken at the first hint of an El Niño, the anticipated west/east reversal of the trade winds and currents would eventually ensure a safe return. It seems likely that exploiting the safety net inherent in an El Niño as an "oscillation" was a stimulus for long-distance voyaging in the southern Pacific – tempting navigators to make longer voyagers for exploration, trading and migration, exploiting an El Niño, than they could otherwise attempt. This suggests the possibility for calibrating a chronology for long-distance migrations and significant voyaging activity from the analysis of climate data. Our aim is to correlate the exploits of these navigators with timings for significant El Niño events recorded in the low Nile proxy data.

It is worth commenting here on the characteristic differences between the history of maritime activity in tropical Polynesia and the maritime history of the Spice Islands where exploration, migration and trading followed major West Pacific Warm Pool currents. We have shown the West Pacific Warm Pool to be a dynamic oceanographic phenomenon, its outflowing currents creating powerful and consistent paths for transoceanic voyaging. ENSO events might also be thought of as oceanographic phenomena, alternately driving and reversing the trade winds and currents in the southern Pacific, alternately constraining and supporting long-distance exploration, migration and trading in tropical Polynesia. But although ENSO events possess oceanographic force (they involve Kelvin and Rossby waves crossing the full width of the Pacific), in general they have an irregular and short-lived impact both on the islands of tropical Polynesia and on the rims of the continents enclosing the Pacific. The strength of ENSO events varies greatly. They might be thought of as irregular climate-modulators. Yet, at their strongest they brought drought and starvation in their wake, so that not only did strong El Niño events generate the oceanographic conditions that made long-distance migration in the southern Pacific more feasible, but they were also responsible for inducing the demographic stress that triggered migration.

The consistent use by Spice Island mariners of West Pacific Warm Pool currents as major ocean paths over millennia was possible because the currents were consistent, responding to the Coriolis effect, to the effectively invariable rotation of the planet. Thus regular trading via the Cinnamon Route was possible in the Indian Ocean. The character of the maritime activity in the two regions was essentially different: current-driven and based in the Spice Islands or wind-driven with a tropical Polynesian base. It seems likely that in tropical Polynesia a significant proportion of long-distance maritime activity, and especially migration, may have been driven by irregular widely spaced intense ENSO events. If this was the case, the simplest way to establish a chronology for tropical Polynesia may be by considering the irregular patterns of extreme ENSO events.

This approach can be thought of as complementing the strong personal focus of most traditional histories which highlight the courage and skill of individual navigators who explored new territories or led oceanic migrations. Given the precision of El Niño low Nile flood proxy data it should be possible, where it is feasible to link persons or events with specific El Niño events, to establish a chronology for some of the major maritime events in tropical Polynesia (whether we are considering migrations forced on tribes by El Niño-driven drought and starvation or conflict and defeat or whether considering maritime opportunities seized by individuals in times of strong El Niño activity).

Our analysis of Spice Island first- and second-wave voyaging in the Pacific has been predominantly concerned with current-driven voyages from the Spice Islands to New Zealand in the southern Pacific and to Japan, Hawaii and America in the northern Pacific. In this chapter our focus moves to voyaging within and from tropical Polynesia which relied on wind power rather than on fast currents. We are concerned with voyages of exploration, which in the first millennium AD ventured as far south as Antarctica, and with migration fleets, which in the medieval warm period carried large numbers of migrants between archipelagoes in Eastern Polynesia and from Eastern Polynesia to Hawaii and New Zealand.

19.4 Dating the First Eastern Polynesian Migrations to Hawaii

One of the best examples of the possibility of deriving a chronology through exploiting the connections between climate-driven events and the precise dating available for solar eclipses and El Niño events can be seen in dating what Fornander describes as the “migration era” in Hawaii. This, he explains, was a period lasting five or six generations in which “the Hawaiian group was visited by expeditions from the Samoan, Society and Marquesan groups, and the Hawaiian expeditions visited them in return” [9]. Writing in 1878, Fornander refers to “the influx of the southern element, about 800 years ago” suggesting a rough dating for the beginning of this migration period of about AD 1080. Kirch, referring to this era, comments:

> Hawaiian oral traditions speak of a ‘voyaging period’ in which great navigators such as Moikeha and Pa’ao made return voyages to ‘Kahiki’ and back. The appearance of new fishhook styles in Hawaiian sites around AD 1200 may indicate contact between Hawai’i and the Society Islands, and there is linguistic evidence for Tahitic borrowings into Hawaiian language. While long-distance voyaging certainly took place, it ceased about A.D. 1300, after which the Hawaiian Islands became completely isolated from the rest of Polynesia [10].

The timing for this migration and voyaging period is tied to dating for the Medieval Climatic Optimum in the northern as opposed to the southern hemisphere. In the northern Pacific the medieval warm period began earlier and ended in about 1300, 100 years before it ended in New Zealand. (The isolation of New Zealand in the Little Ice Age correspondingly occurred 100 years later than in Hawaii.)

From Fornander’s account it would appear that the decision to migrate to Hawaii was triggered simultaneously in a number of southern archipelagoes: Samoa, the Society Islands and the Marquesas. Simultaneous decisions in different archipelagoes suggest high demographic stress induced by a severe El Niño with a widespread effect. The 1096 El Niño was the strongest ENSO event in the period from 968 to 1199, a period of more than 200 years. Its date is in keeping with

Fornander's rough estimate of 1080 for the beginning of the southern migrations. As a level 5 El Niño, it could have provided both motivation and support for the southern migrations. The passage to Hawaii for the migrating canoes would have been speeded by a weakening during an extreme El Niño of one of the strongest currents in the Pacific, the South Equatorial Current which feeds the West Pacific Warm Pool. Reaching Hawaii from the south meant crossing this current. The 1096 El Niño was preceded by a level 3 El Niño in 1085. It is conceivable that Eastern Polynesian explorers may have reached Hawaii during the earlier El Niño, so that when drought and famine became extreme during the 1096 El Niño, the decision to migrate to Hawaii was made by the several groups that Fornander cites. That the 1096 El Niño was the strongest El Niño in 200 years makes it a prime candidate both for motivating and for facilitating the southern migrations.

A total solar eclipse occurs close to the 1096 El Niño. It provides a second means of dating the southern migrations to Hawaii. This eclipse is associated with a sorcerer Kahano-a-newa. Tradition tells us "When the sun vanished and the earth became dark, Kahano brought the sun back again" [11]. Kahano-a-newa was a contemporary (some traditions say the uncle [11]) of Paumakua, whom Fornander saw as a central figure in "the intrusion and influence of the southern element" in Hawaii (p. 197). In the 600-year period from AD 800 to AD 1400 there was only one total solar eclipse in the southern part of the island of Maui where tradition tells us Kahano-a-newa lived. The eclipse, lasting 4 min and 37 s, occurred on 27 February 1104 at 11.02 a.m. (Tony Beresford, personal communication).

This solar eclipse, the date it provides for Paumakua (which we shall see in the next section is relevant for dating the birth of Hema), its closeness to the 1096 El Niño and its correlation with Fornander's genealogically based rough estimate of about 1080 for the beginning of the migration era demonstrate the potential for defining a chronology for oceanic migration in the Medieval Climatic Optimum by exploiting astronomical events and El Niño proxy data in combination with genealogical data.

Clearly in this case we are dealing with the combination of two rare events. The 1104 solar eclipse was the only total solar eclipse in the region in the 600 years between AD 800 and AD 1400. The El Niño of 1096 was the strongest ENSO event in 200 years. The rarity of these events makes chronological precision possible. The closeness of Fornander's estimate shows the robustness of associated genealogical data.

19.5 Dating the Birth of Hema

The birth of Hema has chronological significance for Tahitian, Hawaiian and Maori traditions, in all of which Hema is regarded as an important ancestor. A precise date for Hema's birth can therefore provide a chronological anchor for genealogies spread across the Pacific. This example is useful for illustrating our approach to genealogical data.

In Chapter 12 we told the story of Kai-tangata and the first appearance of cannibalism in Polynesia. We used the story to stress the connection between starvation and cannibalism, for the story mentions a severe famine at the time of Hema's birth. The story has other elements significant for Polynesians. Centrally the story explains how Hema inherited supernatural powers from his demoness mother, Whaitiri, and passed these on to his sons, Tawhaki and Kahiri, and to his grandson Rata. A cycle of hero tales is woven around the four, the recurring motif of which is a son's rescuing a defeated and humiliated father, restoring his mana and sometimes his life. The power of the four heroes to move between the lower world and upper worlds is stressed and linked to the power of Hema's demoness mother whose origin lay in the upper worlds. Abandoning husband and infant to return to her home, Whaitiri nevertheless passed on to Hema and his descendants powers that enabled them to perform deeds outside the scope of normal men. The powers that the four heroes and their descendants inherited from the demoness establish them as important ancestors in prized lines of descent.

Fornander mentions several lines linking Hema and his brother Puna to Paumakua, typically six to nine generations later. We have a secure date for Paumakua who, Fornander tells us, played a central role in the southern incursions in Hawaii which we have dated to 1096. With the mean and standard error derived for a whakapapa generation in Section 18.5, six generations corresponds to an estimated date for Hema achieving manhood of AD 943 $\pm$ 35. For nine generations, we derive correspondingly AD 874 $\pm$ 43. For a severe drought to be remembered in tradition, linked both to the birth of Hema and to the beginning of cannibalism, it is likely that a severe El Niño was involved. The highest level El Niño that accords with the dating range for Hema is the level 5 El Niño of 903. The 903 El Niño was the strongest El Niño in the 125-year period from 842 to 967.

Traditional evidence suggests that the drought at the birth of Hema was extreme: the link of this drought to the first appearance of cannibalism suggests severe famine. There is new evidence that independently confirms the severity of drought at this time. In 2007 Gergana Yancheva et al. published a paper studying the influence of the intertropical convergence zone on the east Asian monsoon. In their own words, the authors

> present high resolution records of the magnetic properties and the titanium content of the sediments of Lake Huguang Maar in coastal southeast China over the past 16,000 years, which we use as proxies for the strength of the winter monsoon winds [12].

The palaeoclimatic evidence they present supports the generally accepted conclusion that the Asian summer monsoon is weaker "during cold phases in the Northern Hemisphere, when the intertropical convergence zone (ITCZ) tends to move southward, as it does during El Niño years". Using sediments from Lake Huguang Maar, Yancheva et al. document climate changes inducing severe drought. They note a very severe drought which they date to AD 907 which had Pacific-wide consequences. Comparing titanium records from Lake Huguang Maar and from the Cariaco basin in the southern Caribbean off Venezuela, they conclude that in AD 907 "major circum-Pacific shifts in ITCZ position catalysed simultaneous events in civilizations on opposite sides of the Pacific Ocean", producing a Pacific-wide drought severe enough to topple the Tang dynasty in China and to bring to an end the Mayan civilization in Mesoamerica.

It seems likely that the Huguang Maar climate proxy data records (less precisely) the severe El Niño of 903 recorded in the El Niño low Nile flood proxy data. The latter has an annual resolution, the former claims only a near-annual resolution.

Rare associated circumstances support the likelihood that the El Niño of 903 was associated with the famine at Hema's birth. Other rare events enable us to date the time of Paumakua (the solar eclipse in 1104 and the level 5 El Niño of 1096). The combination of all these rare events and circumstances makes it possible to date with certainty the moment at which, as tradition would have seen it, a unique source of mana (the supernormal powers passed on by Whaitiri to her son Hema) at Hema's birth became part of an ancestral and tribal domain.

Some comment is needed on the issue of the transition from one generation to another that is recorded in Polynesian genealogies. The level 5 El Niño gives an exact date for Hema's birth at AD 903. Traditionally, in Tahiti and amongst the *Heke* immigrants and their descendants in New Zealand, the moment of transition from one generation to the next is seen as taking place on the death bed of a chief. Polynesian genealogies are seen as recording the transmission of mana usually from a chief to his son as the chief lies dying. The son bites his father's forehead, metaphorically or symbolically taking into himself his father's wisdom, knowledge and spiritual power. Biting his father's perenium, the son takes into himself his father's physical strength and male potency. More than this, he is seen as taking into himself the spiritual power and strength of all preceding chiefs, which has been cumulatively transmitted from chief to chief over generations. Maori thought of this transmission of mana as marking the boundary between chiefly generations. A later date of about 920 for Hema is thus more in keeping with the representation in genealogies of the timing of the transmission of chiefly mana between generations as taking place not at birth but perhaps usually for a chief in young manhood.

19.6 Sketching a Robust Chronology

Our approach to the task of sketching a robust chronology for oceanic migration in the southern Pacific during the Medieval Climatic Optimum, from analysis of traditional genealogies in conjunction with El Niño proxy data, differs markedly from that of earlier prehistorians. Our aim is to link the voyaging activities of navigators, some of whose exploits are well recorded in tradition, with ENSO events recorded in the Nile proxy data, for which dating is accurate to the year.

We are seeking to exploit the interface between the precise chronology that exists for El Niño events in the low Nile proxy data and long-distance voyages recorded in tradition. We have therefore chosen to take the boundary marker for each generation as the moment when a chief's son is acknowledged as having attained chiefly status and/or takes command of a canoe. It is, of course, possible for two or even three generations of navigators to be simultaneously sailing the ocean, as in the traditional story of Toi voyaging to New Zealand in search of his grandson Whatonga and his nephew Turahui.

Chronologically, the way we have chosen for defining the boundaries of generations links the period of peak activity in a navigator's life with events most likely to be recorded in tradition. We take the moment when a navigator takes command of his first *waka* (canoe) as the moment his voyaging generation begins. For example, Kahukura's leading of major migrations in the Pacific, described in Chapter 18, would be correlated not with his father's death and his own accession to power but with the precise year when El Niño conditions both triggered and favoured his leading a migration fleet and settling 2,000 migrants on a range of islands in the Pacific. In Paikea's case, we see his accession to manhood marked, not by the death of his father, but by his leading of a punitive expedition against Tawheta some months before the solar eclipse of 1383. Since chronological precision is our aim, and since our chronology is based on the feats of navigators, this approach has been adopted as pragmatic.

The greater the cultural value ascribed to a genealogy, the more likely it is to be intact and complete. Working within its bounds enables its inherent consistency to assist in shaping a chronology from the genealogical data it preserves. The 93-generation Rarotongan genealogy, reproduced in Appendix 1, derives from the last high priest of Rarotonga, Te Ariki Tara ‘Are, whose training pre-dated European contact [13]. Through this Rarotongan genealogy we can follow the history of maritime activity in the Pacific back to the beginning of the second wave of exploration and migration just after 400 BC. We begin by considering part of this early history for which we have El Niño low Nile proxy data.

19.7 Two Polynesian Voyages of Exploration to the Antarctic

AD 1403, our estimated most likely date for the *Heke*, and the 1383 eclipse on which this dating depends are our starting points. Our first step in constructing a chronology for the prehistory of the southern Pacific is to date two famous voyages from a much earlier period in the exploration of the Pacific. We depend centrally on the low Nile flood data (which as we have seen is a reliable El Niño climate proxy) for dating the famous voyages to the Antarctic of Ui-te-Rangiora and of Te Arutanga-a-Nuku who re-enacted Ui-te-Rangiora's exploit 13 generations or about 300 years later. These two explorations of the great southern ocean and the Antarctic surely rank as the most ambitious and difficult long-distance voyages known to have been undertaken by Polynesian navigators. These voyages sailed into the highest latitudes reached by Polynesian voyagers. In normal conditions the risk of hypothermia would be insurmountable. But both explorers returned home to tell their tales of travelling through seas choked with bull kelp, to have seen strange animals (possibly sea elephants) and snow or ice floating on the ocean "like congealed fat on water" and, possibly in the case of Te Arutanga-a-Nuku, to tell of icebergs: "There is also there [a kind of] rock whose summit pierces the sky with sharp bare cliffs, where vegetation does not grow" [14]. We can only presume that there were unusually high temperatures in the southern hemisphere at both times, that there were high sea surface temperatures associated with clusters of extreme El Niños that remained high for most of the voyage (perhaps till the explorers encountered floating snow and ice), and that unusually strong seasonal winds drove both explorers quickly south towards the Antarctic. Reaching the West Wind Drift the explorers may well have seen snow and ice floating on the ocean and encountered icebergs and bull kelp.

It is not unreasonable to suggest that these daring Polynesian voyages of exploration must have been supported by extreme climatic and sailing conditions probably attributable to the coincidence of freakish global warm peaks with clustered extreme El Niño events.

Te Arutanga-a-Nuku is 15 generations before Paikea on the main Rarotongan line (see Appendix 1). Using the whakapapa generation parameters of Section 18.5, this corresponds to a date for Te Arutanga-a-Nuku of about AD 1000 $\pm$ 55. The Nile records display precisely one short clustered and intense El Niño between AD 900 and AD 1100. Accordingly we propose AD 967 as a dating for the southern voyage of Te Arutanga-a-Nuku.

Ui-te-Rangiora lived 13 generations earlier. Arguing in the same way, we associate his southern voyage with the extreme El Niño years AD 687–696, peaking in AD 689 and AD 694.

The consilience of extreme El Niño events each occurring within a closely spaced cluster of El Niños is remarkable enough to support a claim for a very high likelihood for the voyaging times of both navigators. The period in which we have placed Te Arutanga-a-Nuku's voyage, AD 963–967, for example, lists five El Niños in five consecutive years culminating in one of the two strongest El Niños recorded in the 891 years of Nile flood records. The El Niño pattern for the date we have chosen for Ui-te-Rangiora's voyage is as unusual. The remarkable consilience of chronological data from both climate history and genealogy enables us to claim these dates as pillars for our chronology for Eastern Polynesian prehistory in the period covered by the Nile proxy data.

There is some evidence for higher Antarctic temperatures at the time of both Antarctic voyages. Lamb [15], for example, records the establishing of a "great modern penguin rookery" on the coast of East Antarctica at Cape Hallett (72°S, 170°E), dated by radiocarbon to "between about AD 400 and 700, presumably during a phase of improving climate". This rookery has been occupied ever since. Of relevance to Te Arutanga-a-Nuku's later voyage, Lamb also notes "Earlier explorers of the Bunger Oasis (67 degrees south, 101 degrees east) suggested a period of marked climatic improvement about 1000 years ago, since which there has been only a modest reversion."

19.8 Correlation of Significant Voyaging Activity with Rare Extreme Climate Events

In this section we consider the voyaging activities of another three second-wave navigators: Irapanga who, tradition records, led a migration fleet of six canoes from the Spice Islands to Hawaii; Maui the Navigator whose voyages of exploration took him to both New Zealand and Hawaii; and Tu-te-rangi-marama, whose voyages of exploration took him to New Zealand and the Chatham Islands. All three navigators appear on the main Rarotongan line. All lived before the period covered by the El Niño low Nile flood proxy data. But the voyages of all three can be dated from the Huguang Maar proxy data. (The relevant correlations are shown in Fig. 20.1.)

Irapanga lived eight generations before the Antarctic voyager Ui-te-Rangiora (AD 689) on the main Rarotongan line. This corresponds to an estimate of AD 485 $\pm$ 79. A climate spike in the Huguang Maar data occurs at 1,490 BP (AD 460). The nearest climate spike after this event occurs at 1,407 BP (AD 543). The nearest earlier spike occurs at about 1,620 BP (AD 330), confirming a clear correlation between the genealogical maximum likelihood estimate and the closest climate proxy estimate for an extreme climate event. Close correlation between the major long-distance migration to Hawaii led by Irapanga and an extreme climate event fits the pattern established for the later migrations of the two Antarctic explorers and for the southern migrations to Hawaii in 1096.

Maui lived 15 generations before Irapanga. The Maui recorded in the Rarotongan line (see Appendix 1) is almost certainly Maui the Navigator who met the chieftainess at Orokoroko: his dates match those for Maui the Navigator. His parents' names, which tradition tells us were commemorated by Maui in place names in the South Island of New Zealand, match those in the Rarotongan line. If we accept the date of AD 460 for Irapanga, this places Maui at AD 76, with a standard error of 55 years. This is consonant with dating for the Ambrym eruption at AD 100, which in Chapter 16 we suggested may have caused the tidal wave in which, according to tradition, Maui drowned, close to his homeland. The Huguang Maar climate proxy data has a spike at 1,850 BP (AD 100), corresponding to the accepted dating for the eruption.

Tu-te-rangi-marama appears 18 generations before Maui on the same line. We have a point estimate of 360 BC with a standard error of 60 years. The point estimate coincides exactly with a climate spike in the Huguang Maar data. The closest earlier spike in the data occurs during the global cold period when long-distance voyaging was not feasible. There is no later climate event that is comparable in intensity with that of 360 BC until 202 BC, which is more than two standard errors removed from 360 BC. Thus, given a date of AD 100 for Maui, the 360 BC climatic event is the best candidate for ascribing a date for Tu-te-rangi-marama at a 95% confidence level.

The climate spike at 360 BC shows a southward movement of the intertropical convergence zone such as occurs during El Niño years. Whether severe drought led

Tu-te-rangi-marama to undertake major voyages of exploration in search of lands for his people to colonize, or whether he sought to exploit an El Niño northerly to speed his voyage or New Zealand, or whether he sought to do both, the Huguang Maar proxy data shows that in 360 BC he had a possible motivation and strong El Niño support for his voyaging.

Correlating genealogical estimates with climate proxy dates for these three navigators has utilized a chain of deductions in order to make use of joint information relating to the various voyages. However, not all intervening steps are necessary for subsequent conclusions. For example, Maui can be dated without reference to our conclusion about Irapanga. Given a date of AD 689 for Ui-te-Rangiora and given that Maui preceded him by 23 generations, we arrive at a point estimate for Maui of AD 78 with a standard error of 68 years, and the AD 100 dating based on Ambrym stands as before.

Genealogical estimates and climate data proxy estimates link the voyages of Irapanga, Maui and Tu-te-rangi-marama to rare and extreme climate events. This continues a pattern that is now observable for the span of Pacific voyaging history so far considered for which we have genealogical data: from the main Rarotongan line, that is, the 1,400-year span from Tu-te-rangi-marama to the southern migrations to Hawaii in 1096. Over this span major oceanic migrations and significant voyaging activity can be correlated with rare extreme climate events. That such correlations persistently occur, though extreme climate events recorded in both the El Niño low Nile flood proxy data and in the Huguang Maar data are rare, supports the significance of the pattern.

In the next section we extend our analysis to cover the active voyaging period of the Medieval Climatic Optimum.

19.9 Dating the Navigators' Line

All evidence we have supports the consonance of the *Heke* lines with the main Rarotongan line. We noted in Chapter 18 the genealogical (and therefore genetic) links of some *Heke* migrants to the main Rarotongan line. Our analysis in Chapter 18 of 48 *Heke* lines with common end-points enabled us to establish a 25.5 year mean generation length with a 14.2 year standard deviation. It is not possible working from a single line to achieve such statistical clarity and certainty. Analysis of the 48 *Heke* lines involved a database of 1,540 generations. The main Rarotongan line has only 93 generations. We have therefore used the statistically derived mean generation length of 25.5 with a 14.2 year standard deviation (as opposed to a simple average of 25.2) for the main Rarotongan line as a more refined and therefore likely estimate for the mean generation length of this related line.

Working backwards from the eclipse of 1383 we can use this generation length to create an approximate maximum likelihood chronology for the navigators in the main Rarotongan line from Kuhukura to Paikea – the segment that we have called the Navigators' Line.

As we have suggested, a problem inherent in establishing a chronology from generational data is finding an optimal means of characterizing the transition from one generation to the next. In illustration of this problem, at the time of the eclipse of 1383, Uenuku's son Paikea had already achieved chiefly status, although Uenuku had probably held the reins of power for a generation at this stage and was to hold them for another. If we have Paikea's generation represented as achieving maturity in 1383 (as evidenced by Paikea's involvement in the land-based punitive war party against Tawheta in Tahiti, some short time before the eclipse) we would need to retrospectively date Uenuku's access to chiefly status to 1358 in a chronology with a 25.5 year generation length. Access to chiefly status, or to a navigator's command of a waka, seems to be a more realistic way of determining the gaps between generations – a generation length – than guessed dates for births and deaths. Using climate data, which suggests the most likely times for ocean voyaging, throws emphasis onto the times of maximum adult activity in each generation rather than onto the timing for transmission of tribal mana from a dying chief to his son. Our climate and generational data reach their natural interface in times of action.

Although Hoaki and Taukata do not appear on the main Rarotongan line, the importance of establishing an estimate for Hoaki and Taukata's voyage to New Zealand and so for the bringing of the kumara to New Zealand has led us in Table 19.1 to show their generational if not genetic relationship to Kahukura through their sister Kanioro, one of two women claimed to be the mother of Kahukura.

Our approximate chronology for the Navigators' Line is given in Table 19.1. Dates and strengths for relevant El Niños for each generation are given in the third column. The reader needs to remember that the dates for the navigators (shown in the first column) are unnaturally spaced. Each date is created by subtracting the average generation length of 25.5 years from the date that follows it and rounding up the number obtained. In real life generational lengths are variable. In contrast, the spacing of the El Niño events inferred from the Nile data are natural – literally derived from nature – and so can perhaps usefully be seen as providing a realistic frame for our unrealistically consistent genealogy. A true chronology will lie at the interface between the natural ENSO events and the statistically inferred dates for our navigators' voyages.

Table 19.1 The Navigators' Line (generation length 25.5 years)

Pou-ranga-hua = Kanioro Sister of: *Hoaki *Taukata	Raw genealogy date AD 1200	El Niño date 1200 [5+]
*Kahukura	AD 1230	1230 [5]
*Maru	AD 1256	1244[4]
*Tangiia	AD 1281	1294 [3]
Motoro	AD 1307	
Uenuku-rakiora	AD 1332	
Uenuku-ariki	AD 1358	
*Paikea	AD 1383	1389 [3]

Asterisks denote known long-distance navigators

19.10 A Climate-Correlated Chronology

Considering the correlations made between the El Niño events and long-distance voyaging in Table 19.1, and the pulses of El Niño activity and voyaging activity in the Pacific visually represented in Fig. 19.1, it is perhaps not unreasonable to claim that the greater the severity of an El Niño event, the more likely it is to be associated with a major navigational event. The estimate for the beginning of southern migrations to Hawaii during the El Niño of AD 1096 is an obvious example. In the list of possible correlations we present in Table 19.1, two events stand out as the most likely pillars for the chronology we propose: the 1200 level 5+ El Niño as a marker for the introduction of the kumara to New Zealand by Hoaki and Taukata and the 1230 level 5 El Niño which triggered the migrations led by Kahukura in tropical Polynesia described in Chapter 18. These two events occur close to the genealogical estimates for the individuals involved. The certain date for Paikea associated with the total solar eclipse of 1383 can be thought of as a third chronological marker, with the date of 1403 for the *Heke*, associated with a level 4 El Niño, a fourth. To these dates we can add the earlier pillars for our Pacific chronology: the dates for the explorers Ui-te-Rangiora (689) and Te Arutanga-a-Nuku (967) and for the beginning of southern migrations to Hawaii in 1096. All these dates, like those for the Navigators' Line, are correlated with the severest levels of El Niño and in the case of the Antarctic explorers with strong El Niño clusters. These seven dates bring new chronological clarity to the history of voyaging activity both in the Medieval Climatic Optimum and in the second half of the first millennium AD, which Smith saw as a period of extensive exploration. Chronological information provided from the mean and standard deviation of the generation length of the long Rarotongan line provides a first-approximation guideline also in Chapter 20. The importance of this line, which spans 1,770 years, and the robustness and relevance of its generational estimates are discussed in that chapter.

Figure 19.1 also shows that Maru, who is said to have voyaged to New Zealand from Eastern Polynesia, may have been supported in his voyaging by a level 4 El Niño in 1244. His nephew and adopted heir Tangiia might have been supported by a Level 3 El Niño in 1294. It is conceivable that this El Niño might have assisted Tangiia's return voyage from Indonesia after his defeat and the death of his sons and his voyage to Easter Island to bring his adopted son to Rarotonga. But these correlations of voyaging activity involve less severe El Niño events and are not as close to generational estimates.

Figure 19.1 shows that in the 550-year period from AD 850 to the *Heke*, there are four level 5 and two level 5+ ENSO events. The level 5 El Niño of 903 is linked with famine at the time of Hema's birth, that of 1096 with the southern incursions into Hawaii, the third in 1230 with Kahukura's migrations. The first level 5+ El Niño in 967 is linked with Arutanga-a-Nuku's Antarctic voyage and the second with Hoaki and Taukata's voyage to New Zealand. This leaves only the 1144 level 5 El Niño without a correlation.

Figure 19.1 shows the strongest El Niño support for long-distance voyaging in the period AD 650–1008, the time, as we have noted, which Smith saw as the time

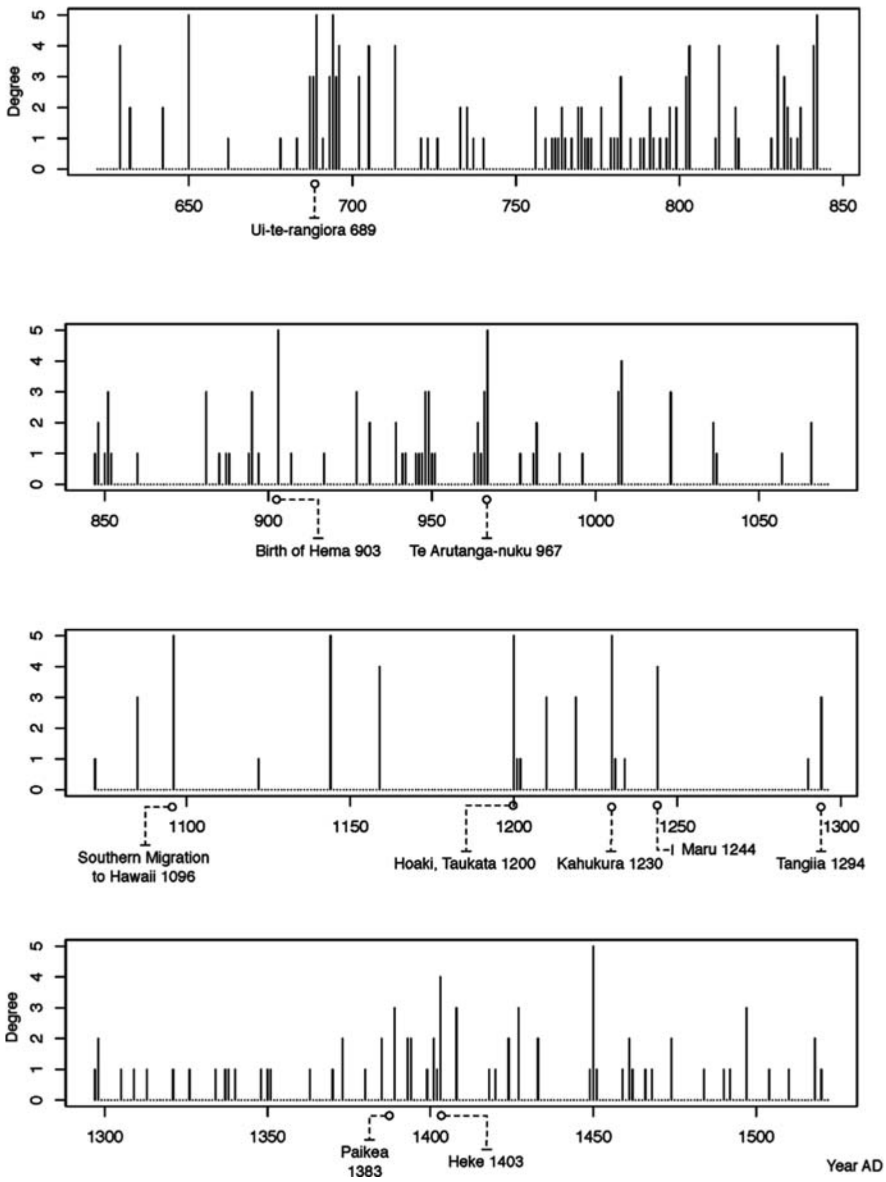

Fig. 19.1 A diagram linking the birth of Hema, southern migrations to Hawaii and voyages of Polynesian navigators with the intensity and frequency of El Niño events recorded in the low Nile flood proxy data

of greatest exploratory activity. If El Niño events are seen as a means of equalizing or dispersing heat in the Pacific, it is possible that the greater El Niño activity of this earlier period may suggest far warmer conditions in the southern than in the northern hemisphere in the first millennium AD. Voyaging into the Antarctic could be seen as an extreme example of the discrepancy in climate between the two hemispheres. Contrasting the history of Norse and Polynesian voyaging and migrations before and during the Medieval Climatic Optimum (cf. Chapter 12) supports this interpretation.

The annual precision of the El Niño dates and the wider bounds of generational dating will have only a broad consilience because their bounds apply so differently. Generation lengths vary from one generation to the next and the overall generation length average will hide many anomalies. Some of the suggested dates for the Navigators' Line are exact, that is, they closely match the El Niño events closest to generational estimates, as, for example, for Kahukura and Hoaki and Taukata. Without undermining the overall usefulness of the suggested chronology, others, those for Maru and Tangiia for example, will not. In an archaeological context in which, as Kirch and Green note, "fully 80 percent of the reconstructed Ancestral Polynesian artifact array is missing from our archaeological assemblage" [16] ,the chronology we have sketched can be seen as contributing to the available dating evidence. It is interesting to note the broad agreement of some of the dating estimates of Smith, Tregear and Fornander with ours, though their estimates were derived without the benefit of El Niño or eclipse datings. That this is possible suggests the reliability of well-preserved traditional histories and of the genealogies that underpin them and the inherent value of both as historical sources.

19.11 El Niño-Driven Migration in the Pacific

The global climate patterns, and especially the recurrence of El Niño-driven droughts that we have seen as shaping the prehistory of Eastern Polynesia in this late warm period, must have found an echo in all the populated archipelagoes of the tropical Pacific. Repeating patterns of conflict over land and resources, linked to drought, will time and again have made migration mandatory for the defeated and starving. In other words, in the Medieval Climatic Optimum, it is hardly surprising that the pulse of long-distance migration and, possibly to a lesser extent, the pulse of exploration and trading activities in the Pacific were tied to very strong to extreme ENSO events. The Hawaiians assumed that Captain Cook and his crew were driven to explore the Pacific by famine. This assumption suggests a very long acquaintance with famine in tropical Polynesia. Very strong to extreme El Niño events would have been needed to trigger droughts severe enough to precipitate long-distance migrations. Likely timings for long-distance drought-driven migrations can be read from Fig. 19.1. However, as we stressed in Chapter 12, population size in relation to resources is of key importance in the generation of demographic stress and consequent migration. On a small island with limited resources, less severe drought, triggered by a lower level El Niño, may have been sufficient to necessitate migration, though this may have involved only local or short-distance migration or the establishment of a temporary settlement on a small uninhabited island in the region.

The pattern we have observed for the 1,400-year span from Tu-te-rangi-marama to the southern migrations to Hawaii clearly holds for the period of the Navigators'

Line. This is not surprising given the evidence presented in Chapter 12 for the drought-driven history of tropical Polynesia and of the west coast of North America during the Medieval Climatic Optimum. Long-distance oceanic migrations spanning this global warm period, from the southern migrations to Hawaii in 1096 to the last migration to New Zealand on the cusp of the Little Ice Age, appear to have been triggered either directly by El Niño-driven drought within tropical Polynesia or by the demographic stress and conflicts it engendered. The combination of necessity and opportunity clearly drove long-distance migration in this global warm period, as it appears to have done in earlier warm periods. The pattern of migrations tied to global warmth Lamb claims is universal, whether the migrations are land-based or oceanic.

Drought-driven long-distance migrations in the Medieval Climatic Optimum from Eastern Polynesia to Hawaii and to New Zealand involved far more that the ferrying of tribal groups to new lands. The seizure of territories by immigrants and their imposition of their own cultural prerogatives and even, as in the case of Toi (see Chapter 16), the imposition of their language on indigenous peoples sometimes had far-reaching consequences. For example, the introduction of the kumara by Hoaki and Taukata and by other medieval migrants from tropical Polynesia to New Zealand, as we saw in Part II, significantly affected demographic outcomes in that country. The unusually warm conditions of the Medieval Climatic Optimum both assisted migrants' passage to New Zealand and enabled them to establish kumara once they had arrived. Ultimately it was because horticulture, mostly based on the kumara, so strongly affected survival in New Zealand during the Little Ice Age that horticulturally skilled Eastern Polynesian medieval migrants and their descendants eventually gained an unusual degree of ascendancy over the indigenous peoples who so vastly outnumbered them at the time of their arrival.

The *Heke*, the last migration fleet to reach New Zealand, also had a substantial effect on the history of the country, partly because it was such a carefully planned and successful migration. Far from being a "myth", a pakeha construct, it was solidly rooted in a traditional Polynesian pattern whereby a substantial group of people and their complex ark of resources were translocated to another island or archipelago by a fleet of canoes. In the Little Ice Age, clarity of purpose, adaptability, the urge to create a new world, sometimes after facing defeat in the old, gave the *Heke* migrants a psychological edge over the populous, demographically declining tangata whenua. With ceilings of sustainability already breached in many tribal areas, the energy of the new migrants could be seen in their adaptation of the kumara to grow in conditions outside its natural ambit. Lifting tubers annually so they could be protected from frost and replanted in the spring, they turned a tropical perennial into an annual food source that, in the optimal growing areas in the north of the North Island, was able to provide some insurance against starvation following a devastating loss of biota. El Niño-induced famine had been commonplace in tropical Polynesia probably since the birth of Hema in AD 903. The medieval migrants used horticulture in New Zealand, as they had done in Eastern Polynesia, to fight starvation. Their success in New Zealand can be seen as a product of their long experience in dealing with starvation and stress in the tropics, the conditions that drove them to migrate. Their success as immigrants arose from the combination of will, adaptability, martial prowess and horticultural expertise learnt in an Eastern Polynesian homeland recurrently subject during the Medieval Climatic Optimum to El Niño-driven drought, starvation, conflict and to enforced migration for the defeated and the starving.

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Chapter 20
Dating the First Migration to New Zealand

Abstract Two long genealogies preserved in the Chatham Islands record a 3,000-year-long history for the Moriori inhabitants. Major events in that history – one of extreme isolation – are tied to specific ancestors and so placed in a defined time line. This time line intersects the main Rarotongan line through a famous early ancestor common to both lines over 2,000 years ago. Through this connection it is possible to translate the Chatham Island time line into a western chronology and so, for example, to estimate dates both for the first settlement of the Chathams and for the first settlement of New Zealand. These estimates can be sharpened using new high-resolution climate proxy data based on the analysis of sediments from Lake Huguang Maar in China. This provides precise dating for events for which the two Moriori lines provide genealogical estimates. A strong pattern emerges from climate-based analysis in Chapters 19 and 20: the correlation in all periods for which there is genealogical data, of voyaging activity with rare extreme climate events. These events can be precisely dated using high-resolution climate proxy data.

Keywords Moriori genealogies · Lake Huguang Maar climate proxy data · Near-extinction event · Law of non-violence · Low Maori genetic diversity

20.1 Introduction

The Chatham Islands lie in the Great Southern Ocean 870 km east of Christchurch, New Zealand. Two long genealogies record a 3,000-year-long genealogical history for the Moriori inhabitants. Major events in that history – one of extreme isolation – are tied to specific ancestors and so placed in a defined time line. This time line intersects the main Rarotongan line through a famous early ancestor common to both lines over 2,000 years ago. Through this remarkable connection, it is possible to translate the Chatham Island time line into a western chronology and so estimate times both for the first settlement of the Chathams and the first settlement of New Zealand.

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Perhaps the most striking consequence of the isolated history of the Chatham Islands is the preservation of two genealogies which record history over 154 generations. The same isolation, we saw in Chapter 17, preserved in the Chatham Islands' ancient Lapita forms of totemic Creation myths linked to tree worship. If these myths can be thought of as a cultural time capsule, we can think of these two Moriori genealogies, and the sparse historical notes linking events to specific ancestors in the two lines, as encoding a long prehistory recorded in genealogical time. The two Moriori genealogies, communicated to Alexander Shand in 1868, together with the important Rarotongan genealogy communicated to S. Percy Smith by the Rarotongan high priest Te Ariki Tara 'Are, are presented in Appendix 1.

The traditional historical notes accompanying the two Moriori genealogies highlight the extreme isolation of the Chatham Islands. All recorded events of significance are moments at which two and a half thousand years of isolation were broken by arrivals from outside a closed world.

The first and most important arrival recorded is that of Tu-te-rangi-marama, a famous early navigator who appears on the main Rarotongan line. It should be noted that although this line was preserved in Rarotonga, its earliest stages almost certainly relate to ancestors living in Island Southeast Asia: in the Spice Islands or Wallacea or possibly Borneo (in Atia-te-Varinga-nui or Avaiki-te-varinga-nui). It is highly likely that Tu-te-rangi-marama, who is recorded in the Moriori Tamahiwaki line, lived in Island Southeast Asia and voyaged to the Chathams from this area. Not only did he leave descendants in the islands but he is credited with teaching the Chatham Islanders to make flax mats. In Rarotonga he is also remembered as a technological innovator, though he is most celebrated as an early navigator and explorer.

20.2 A Chronicle of Survivors

A singular feature of the two Moriori genealogies makes them an unusually reliable source. They reflect a culture that survived against the odds on a tiny group of islands in the Southern Ocean through creating a strictly controlled and regulated society. In Section 20.5 we consider at some length Tim Flannery's discussion of forces driving small isolated societies towards extinction [1]. He quotes the finding that the minimum size required to ensure the survival of a mammalian population is 500. Smaller numbers imply lower genetic diversity with attendant risks of genetic disease and greater risks from environmental disasters which could reduce populations below the limits needed for survival. Flannery quotes examples from Flinders Island in the Bass Strait and Kangaroo Island which lies off the coast of South Australia. In both these islands populations isolated by the last Ice Age floods became extinct.

The size of Flinders Island is about 1,800 km^2. Flannery estimates that it had a population capacity of about 400, that is, 4.5 km^2 per person. Its population survived for about 4,500 years before it became extinct. The isolated population on Kangaroo Island, which has a much greater area (3,890 km^2) but more limited food resources, survived for only 2,250 years. The Chatham Islands have a combined area of 960 km^2. Their population in 1835, 44 years after the European discovery of the islands and 25 years after the arrival of the first sealers, was estimated at 1,600 [2]. By 1835 a significant proportion of Moriori had succumbed to European diseases. Alexander Shand estimated from Moriori oral evidence that a series of influenza and measles epidemics between 1828 and 1832 wiped out half their population. Europeans claim Moriori lost only one-fifth of their population from European diseases before 1835 [2]. The Moriori estimate suggests a pre-contact population of more than 3,200. The European estimate claims 2,000. With a pre-contact population of between 2,000 and 3,200 plus, the area per person before European contact would have been between 0.3 and 0.5 km^2 per person. Thus the density of people in the Chathams would have been between 9 and 15 times that on Flinders Island.

The food resources available on Flinders Island seem to have been comparable to those in the Chathams: colonies of seals, numerous birds (including Cape Barren geese not found in the Chathams) and, in season as in the Chathams, vast quantities of migrating mutton birds which could be cooked and preserved in their own fat (as Maori preserved the moa in New Zealand). Flinders Island had the advantage of a lower latitude (higher temperatures).

How did Moriori with a substantial population in relation to area, limited to a hunter/gatherer lifestyle, avoid extinction? The answer we believe lies in their evolution of a tightly controlled society. Most hunter/gatherers find means to preserve a stationary population, birth control and infanticide amongst them. As commented in Chapter 11, such societies have to maintain a population size below the carrying capacity of the land to protect themselves from population losses in times of drought or environmental disasters (tsunamis, cyclones, floods, etc.). Moriori depended on seals for protein and clothing. They maintained seal colonies by culling only old males. Like the tangata whenua in New Zealand, they probably had hunting protocols to preserve the birds they hunted.

For controlling human population levels they employed two means. The first was their adoption of a law of non-violence (discussed in Section 20.6), the second, castration of a proportion of male babies. For over 2,600 years, until the arrival of Europeans, they were able by these means not only to avoid extinction but also to support a substantial population in relation to area.

A significant consequence of their following these strategies is that the generation lengths of the two genealogies we analyse in this chapter may well have been virtually constant throughout Moriori prehistory. This would ensure the accuracy of the chronological estimates we can obtain through analysis of these two genealogies.

The closeness of the two mean generation lengths of the two genealogies which we derive in the following sections (21.21 years for the Tamahiwaki line and 21.04 for the Maikoua line) shows their consonance one with the other, as is perhaps to be expected given a controlled population size, conservation of resources and strict adherence to a law of non-violence which ensured no loss of life through war or personal conflict.

Until European contact, the Moriori were free from invasion and conquest and internal conflict. The preservation of accurate traditions in these circumstances can be expected.

The generation length of the two Moriori lines suggests a far lower life expectancy than for tropical Polynesia. The main Rarotongan line has an average generation of 25.5 years, perhaps reflecting the difference in life expectancy between those living in tropical Polynesia with its abundance of fruits and vegetables and a long horticultural tradition and those living as hunter/gatherers in the cold harsh Chatham Islands.

20.3 Establishing a Generation Length for the Tamahiwaki Line

To establish a generation length for the Moriori lines entails finding at least two independently derived chronological markers. One marker is available from the date at which the lines were recorded in writing. The obvious occasion where another might be available is the arrival in the Chatham Islands during the Medieval Climatic Optimum of the Eastern Polynesian migration canoes, the *Rangimata* and *Rangihoua*. Alexander Shand, who recorded the two long Moriori genealogies, provides the information that the builder of the *Rangimata* canoe was Ru of the Rauru clan, whose wife Pe was a niece of Kahukura [3]. In the last chapter we established a secure date for Kahukura of AD 1230. Adding a generation to this gives a date for the *Rangimata* of about 1255. With the transmission of the Tamahiwaki line fixed at 1868 (adding two generations to its length because Tamahiwaki was a great-grandfather in 1868) we have a span of 613 years and 27 generations. This provides an initial estimate for a generation length of 22.7 years. The Maihoua genealogy does not show the generation in which the Eastern Polynesian canoes arrived. We can obtain a second estimate for the generation length of the Tamahiwaki line from the arrival of Tu-te-rangi-marama.

In the last chapter we dated Tu-te-rangi-marama to 360 BC. Computing an average generation length for the Tamahiwaki line from Tu-te-rangi-marama in 360 BC to 1868, a span of 2,227 years and 105 generations, gives a generation estimate of 21.21 years, versus the estimate of 22.7 over only 613 years. The confirmation of the date for Tu-te-rangi-marama through the Lake Huguang Maar climate proxy gives weight to this estimate made with a longer database.

20.4 Computing First Settlement Dates for the Chatham Islands and for New Zealand

Using the Moriori Tamahiwaki generation length of 21.21 years, it is simple to estimate the time for the first settlement of the Chatham Islands. Rongomaiwhenua, in whose time, Moriori tradition tells us, men first came to the Chathams, lived 21 generations before Tu-te-rangi-marama. With a generation length of 21.21 years this gives a date for the first settlement of the Chatham Islands of 805 BC. Given the existence of an intense cold period at this time, it seems possible that the first settlement of the Chatham Islands may either have been the result of an enforced migration from New Zealand or perhaps more probably of an attempted migration from the east coast of the South Island to the warmer North Island in which the migrants' canoe was blown off course and carried to the Chathams. (Flotsam and jetsam from the east coast of the North Island are regularly carried there by currents.) Michael King reached a similar conclusion of accidental migration [4].

Such is the mana attaching to the founder of a new settlement, the leader or member of a major migration, that it is usual for a genealogy to begin with his name and the tribe to trace its descent from him in the new land. This widespread practice gives us the confidence to assume that Tokoroa, the first man listed in this genealogy (as opposed to the 30 heaven-born ancestors that precede him) was either the leader of the first migration to New Zealand or one of the original first-wave Spice Island Lapita-age migrants from whom the Chatham Islanders trace their descent.

This being the case, the genealogy yields the information that the first settlement of New Zealand by Moriori ancestors occurred 27 generations before the time of Rongomaiwhenua. This gives a date for the first settlement of New Zealand of about 1378 BC, assuming an average generation length of 21.21 years. If it is argued that a longer generation length could be expected in New Zealand as opposed to the less well resourced Chatham Islands, this would give a correspondingly earlier date. The near-extinction event in New Zealand discussed in the next section may, however, have been associated with lower life expectancies, as a result, for example, of the loss of technical knowledge which formerly had increased chances of survival.

The Lake Huguang Maar climate proxy data suggests a correction of the genealogically based estimate of 1378 BC for the first settlement of New Zealand. A major climate spike at 3,307 BP corresponds to a date of 1358 BC, 20 years later than the generational estimate. This climate spike represents a rare event. It is the only major climate spike in 450 years. It is 300 years before a later climate spike and 150 years after an earlier one. The pattern, observed in the preceding chapter in which major oceanic migrations are linked to rare intense climate events, suggests the likely correlation of such an event with the arrival in New Zealand of a migration fleet carrying the first New Zealand colonists.

For reference in the following sections, we provide a copy of the last 4,500 years of the Lake Huguang Maar palaeoclimate records, indicating the correlations (A to L) that we suggest between major spikes in the data and major migrations and significant voyages recorded in tradition. A list of BC/AD dates, corresponding to the BP calendar dates utilized in presenting the climate records, is given in Fig. 20.1 for the traditional events we tabulate.

Suggested correlations of major climate spikes with genealogical estimates for events recorded in Polynesian tradition:

A 720 BP (AD 1230, Level 5 El Niño, Kahukura's migrations)
B 750 BP (AD 1200, Level 5 + El Niño, Hoaki and Taukata's voyage to New Zealand)
C 854 BP (AD 1096, Level 5 El Niño, Southern migrations to Hawaii)
D 983 BP (AD 967, Level 5+ El Niño, Ui-te-Rangiora's Antarctic voyage)

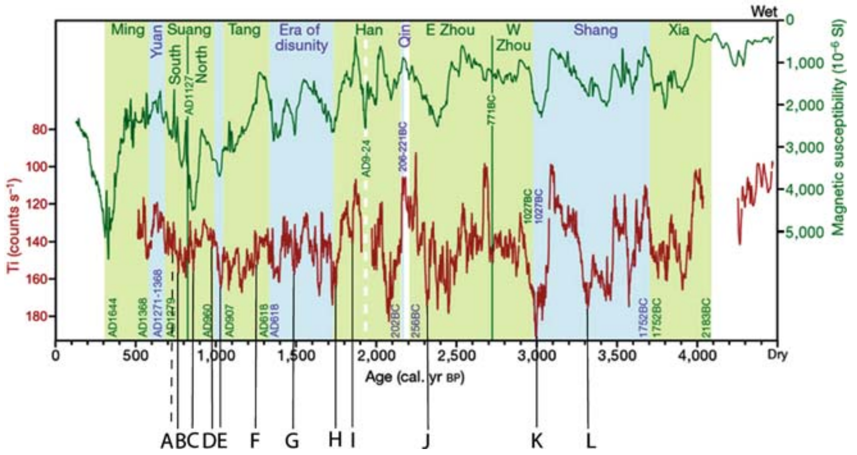

Fig. 20.1 The Lake Huguang Maar palaeoclimate records during the past 4,500 years in the context of major events in the cultural history of China and the Pacific. Reproduced with permission from Nature Publishing Group

E 1,043 BP (AD 907, Level 5 El Niño (AD 903), famine at Hema's birth)
F 1,261 BP (AD 689, Level 5 El Niño, Te Arutanga-a-Nuku's Antarctic voyage)
G 1,490 BP (AD 460, Irapanga's migration to Hawaii)
H 1,764 BP (AD 186, Eruption of Taupo)
I 1,850 BP (AD 100, Ambrym eruption, death of Maui the Navigator)
J 2,309 BP (360 BC, Tu-te-rangi-marama's voyage to New Zealand)
K 2,976 BP (1027 BC, Eruption of Taupo, obvious candidate for causing the near-extinction event recorded in Moriori traditions)
L 3,307 BP (1358 BC, First settlement of New Zealand)

20.5 A Near-Extinction Event in the Early History of New Zealand

The first detail given in the Tamahiwaki Moriori genealogy relating to the early prehistory of New Zealand is the brief note that ten generations before Rongomaiwhenua, his ancestor Tangaroa-matahi ate raw food (about 1018 BC). Superficially this seems an odd remark, an odd fact to be remembered and handed down carefully over 3,000 years. Tim Flannery provides a context in which the importance and implications of this traditional knowledge readily become clear. He provides a context in which this brief historical note can be read as a memory of a traumatic near-extinction event in the early history of New Zealand.

In his book, *The Future Eaters* [1], Flannery describes the increased risk of extinction associated with isolation. With his permission, we quote parts of his explanation. He explains that isolated populations smaller than about 500

> suffer continual loss of genetic diversity and also become susceptible to genetic disorders through inbreeding. Their small size also makes them susceptible to chance events, such as an imbalance in the birth rate (for example, a preponderance of boys), disease and disaster (for example, mass food poisoning). These factors dictate that such small, isolated populations are doomed to extinction (p. 264).

Flannery tellingly illustrates the risks of isolation through discussion of the isolated history of Tasmanian aborigines. Like Kangaroo Island and the Bass Strait islands, Tasmania was part of the Australian mainland till it was turned into an island by the drowning of Bass Strait in the Ice Age floods 11,500 and 7,500 years ago. Flannery comments:

> The sole surviving Aboriginal population inhabiting a temperate Australian island was that living in Tasmania. Tasmania is large enough to support some 5000 Aborigines living traditional life-styles. This is some ten times more than the absolute minimum size necessary for long-term survival. But is a population of 5000 large enough to maintain a complex material culture? Recent archaeological discoveries suggest that it was not. . .
>
> The French savants of the Baudin Expedition, who observed the Tasmanians in 1802, were amazed that even though the Tasmanians lived in an often bitterly cold climate, they lacked clothing. Extraordinarily, they also lacked the ability to make fire. Mannalargenna, one of the last of the Tasmanian Aborigines to live a traditional life, told of what would happen if a group's fire was extinguished. He said that people had no alternative but to eat raw meat while they walked in search of another tribe. Significantly, one of the universal laws among the Tasmanians was that fire must be given whenever requested, even if the asker was a traditional enemy who would be fought after the gift had been given.
>
> The French were also struck by the fact that the Tasmanians did not eat fish, even though they were abundant in Tasmania's coastal waters. Francois Peron records that when members of the Baudin Expedition offered some fish which they had caught, the Tasmanians expressed amazement and horror. This was not an isolated instance, for earlier, in 1777, members of Cook's third expedition recorded that Tasmanians reacted with horror or ran away when fish were offered to them (pp. 263–264).

Flannery comments on the limited material culture of the Tasmanians: they "had no hafted implements (such as axes), no implements made of bone, no boomerangs or spear throwers, no dingoes and no microlithic stone tools" (p. 265). This fact led to Tasmanians being classed as the world's most primitive people. But, Flannery tells us, study of Tasmanian campsites occupied over the last 7,000 years shows that the Tasmanians once had bone tools, including awls, reamers and needles, undoubtedly used for making skin cloaks similar to those used by Aborigines of southern Australia. He notes that the variety of bone tool found in Tasmanian middens "dwindles with time, until eventually, about 3500 years ago, the last of them disappear from the archaeological record" (p. 266). And, Flannery notes, older archaeological sites show that fish once formed an important part, perhaps 10%, of the Tasmanians' diet. Suddenly, about 3,500 years ago, the remains of fish cease to appear in refuse dumps (p. 266).

Flannery argues that the most plausible explanation for the simplification of material culture

> seems to lie in the unique isolation and small population size of the Tasmanians. The theory goes something like this. A small group of people are less likely to come up with technological innovations than a larger group. If the group is completely isolated, then new ideas

> cannot reach it. Because of this, innovation in material culture is slowed. Because the population is small, activities and knowledge may be lost simply through the early death of skilled people before they can pass their skills to the next generation.
>
> Losses such as that of clothing and the ability to make fire may have resulted from rare, early deaths occurring over a long period of time. The 5000 Tasmanians lived scattered in small groups. It may be that only one or two people in any one group had all the skills necessary to make bone needles and prepare skins. Over 10,000 years there is a high chance that the few such specialists in any one area would, at some stage, die before they could pass their skills on. Repeated chance events like this might have led to the loss of many skills that require specialised knowledge. These may have included the ability to make bone needles and thus clothing, fire-making equipment, hafted tools, boomerangs and spear throwers.

Flannery develops this interesting argument further. We present his argument in detail because it casts light on the problems almost certainly encountered by the Lapita colonists isolated in New Zealand by a severe global cold period after about 1000 BC and on the problems encountered by the most isolated Polynesians of all, the Moriori of the Chatham Islands:

> If the population is small enough, there may be strong evolutionary pressure to dispense with high-risk activities. This is because risks that are acceptable for large populations can threaten the very survival of smaller ones. The loss of fish from the Tasmanian diet may be an example of a high-risk activity that is strongly selected against and thus lost, in small populations.
>
> Eating fish can be a risky business, because occasionally a dinoflagellate bloom known as a 'red tide' can lead to mass poisoning. The simultaneous death of hundreds of people in a large human population is a great personal tragedy, but it poses no threat to the survival of that society because the statistical chance of losing all members of one age group or sex is tiny. Such a poisoning in a small population, however, can be a disaster for the entire group. This is because, through chance, it may kill a significant proportion of the women of child-bearing age, or all of the older and more knowledgeable individuals. In order to avoid such catastrophic events, extreme conservatism may be selected for in small societies. This is because in evolutionary terms it may be better to forego the benefit gained from eating such 'dangerous' food as fish, rather than risk an extremely rare but catastrophic poisoning event. This very necessary adaptation of course carries a severe penalty, for resources normally available to people in other circumstances are denied to small groups in already vulnerable situations.
>
> Incidentally, the final loss of bone needles from the archaeological record occurs at about the same time that fish disappear, suggesting that these events may be related. If a large number of Tasmanians did perish due to fish poisoning some 3500 years ago, it may be that the last people who possessed the knowledge to manufacture and use bone points died in the catastrophe before their skills could be passed on (pp. 268–169).

That isolation and a near-extinction event may have led to the loss of material culture in New Zealand, and that initially, as with the Tasmanians, it may even have led to the loss of fire-making, is suggested not only by the Moriori tradition that Tangaroa-matahi and his descendants ate raw food but by the anger of Maui the Navigator, recorded in tradition, at the "stupidity" of the descendants of the first New Zealanders, their loss of traditional skills, their technological impoverishment during perhaps 1,500 years of isolation in New Zealand. It appears that tradition, offering a faithful account of the remarkable historical encounter of Maui with the people of Orokoroko, remembered the technological disparity between the two societies that arose from the long isolation of the people in New Zealand and possibly from their experience, a thousand years before, of a near-extinction event comparable to that Flannery suggests for the Tasmanian Aborigines 3,500 years ago. If such an event took place in about 1018 BC, as genealogical evidence from the Tamakiwaki Moriori genealogies suggests, it would have occurred when, or just before, extreme global cold conditions were sealing New Zealand into a long period of cultural, genetic, technological and linguistic isolation, with all the attendant risks for a small society that Flannery has described.

Seeking for a possible cause for a near-extinction event occurring in New Zealand in about 1018 BC, we found that geologists Goff, Rouse, Jones et al. have estimated that a significant eruption of Taupo took place close to this time. This early eruption has a calibrated dating of 2,765–3,150 BP (or 1200–815 BC) [5]. The genealogical estimate of 1018 BC for this extinction event is in the mid-range of the geological estimate.

This eruption is represented in the Lake Huguang Maar data as the most intense event in 4,500 years. This suggests that it may have been extreme enough to provoke a "nuclear winter", leading to an extreme and possibly prolonged southward shift of the intertropical convergence zone. This could have caused a long-lasting major drought in the Pacific and on its continental rim. It may have caused a temporary global cold period. It is even conceivable that it may have triggered, or been one of the factors triggering, the 600-year global cold period that began at about this time and halted long-distance voyaging till about 400 BC. For there is no significant climate spike in the Huguang Maar data for 550 years following this event. Yancheva et al. date the event to 1027 BC. This provides a clear correlation with accepted dating for the beginning of the global cold period and suggests a chronological correction of only nine years for the near-extinction event in New Zealand recorded in the two Moriori genealogies and associated traditions.

It has been suggested that the well-known later Taupo eruption of AD 186 was associated with tsunamis, despite it being an inland event. Perhaps it triggered undersea eruptions along the long Kermadec chain of undersea volcanoes that lies off the east coast of New Zealand. If the earlier Taupo eruption of 1027 BC triggered a nationwide tsunami, coastal settlements may well have been destroyed with significant loss of life.

Very small populations are genetically and physically vulnerable to even local catastrophes. That a nationwide tsunami, perhaps only 330 years after first settlement, may have led to a near extinction of an early population is not surprising. Based on a power law estimate for a growth rate of 0.307% per annum, a first settlement date of 1358 BC and a founder population of 289, the population of New Zealand would have been only about 797 in 1027 BC. Were this population to have been halved through a near-extinction event, it would have fallen below the level needed for survival and may have remained below that level for some time. With a population of only about 797 before the eruption, it is unlikely that any group would have migrated to the North Island by this date – a circumstance that may have protected the first colony from extinction. In the South Island associated tsunamis and earthquakes may still have been perilous.

On comparison of the spike with that recording the later Taupo eruption, usually dated to AD 186 and precisely recorded at that date in the Lake Huguang Maar proxy data (1,764 BP), it is clear that the well-known later eruption was much weaker. It may nevertheless have caused survival problems for exposed groups, from tsunami, earthquake and ashfalls.

The loss of fire recorded in Moriori tradition is probably representative of a more general loss of technologies vital to survival, such as Flannery describes for the isolated Tasmanians. But in 1027 BC, the loss of fire-making, at a time when cold, drought and possibly tsunami inundation were impacting on biota, would have made life difficult for survivors. Loss of biota would probably not have directly affected survival for a small population but it may have made food-gathering more arduous. As inadequate nutrition and strenuous physical activity are known to increase age at menarche, to reduce female fertility and to increase the level of infant mortality [6], a reduction in population growth rates after a near-extinction event may have occurred, slowing demographic recovery. Given the traumatic nature of a near-extinction event, it is hardly surprising that it was remembered in tradition, the information passed down over a span of 1,800 years.

20.6 The Moriori Law of Non-violence

Ten generations and just over 200 years after the possible near-extinction event recorded in connection with the Tamahiwaki genealogy, the first settlers arrived in the Chatham Islands (805 BC). A deliberate colonization of the Chathams seems improbable. Descendants of first-wave colonists in New Zealand would hardly choose to go to a harsher and more isolated location during an extreme cold period. Perhaps a group had decided to return to their original homeland – a hazardous proposition during a global cold period – or more probably just to move to the North Island where it was warmer. If their route had taken them up the east coast of New Zealand, a storm could have driven them to the Chathams. If their canoe was damaged as it beached in the Chathams, and there were no canoe builders aboard or the canoe builders aboard died before they could pass on their knowledge, permanent exile would have been the outcome.

Some such scenario is needed to explain the presence of women aboard the canoe that, either accidentally or deliberately, conveyed the first Chatham Islanders, to such an isolated archipelago in the Great Southern Ocean. A fishing boat blown to the Chathams in a storm would probably have had no women aboard.

Sustaining a population in the Chatham Islands over 2,500 years represents an achievement in adaptation to a harsh environment and an achievement in maintaining an ecological balance. The evolution of a law and culture of non-violence probably played a significant role in avoiding subsequent extinction. As we suggested above, a small population could not survive casualties among young males from personal animosity or tribal warfare. A controlled population size, without growth or loss, was vital for humans and for the seals and birds on which humans depended. Death through violence was outlawed.

Possibly we can regard the evolution of a law of non-violence in the Chathams as an example of the extreme conservatism Flannery speaks of as being necessary for a small society to survive in isolation. The risk that tribal conflict might reduce genetic diversity is too great for conflict to be allowed to erupt. In the Chatham Islands the risk of an uncontrolled escalation of violence was contained by allowing one-to-one combat to settle a dispute with the proviso that the combat ended as soon as the first blood was drawn. It is a terrible irony that this strategy, which protected an isolated society for two and a half thousand years, led Moriori into a position of extreme vulnerability when they were attacked in 1835 by aggressors from Te Ati Awa, a Maori culture with quite opposite cultural prerogatives.

Michael King [7] quotes the traditional story of the origin of the Law of Nunuku, the Moriori law of non-violence. The fact that cannibalism is mentioned in the tradition and that the warring tribes in the Chathams, Wheteina and Rauru, were continuing the conflict that drove them from Eastern Polynesia and led to their migration to the Chatham Islands makes it very clear that medieval migrants, rather than the indigenous Hiti, were involved. This being the case it seems likely that a non-violent tradition may have been in place in the Chathams a long time before, and that tradition is describing the imposition of a much older Moriori custom or law on the medieval migrants. Indigenous tribes in New Zealand saw the medieval migrants as bringing cannibalism and violence with them from Eastern Polynesia. The same pattern seems to be true for the medieval migrants to the Chathams. The migrants in the *Rangimata* canoe are said to have been captained by Mihiti of the Wheteina tribe and the *Rangihoua* also brought members of the Wheteina tribe to the Chathams after their defeat by the Ngā Rauru in their homeland. The presence in the Chathams of two tribes who had been involved in conflict in Eastern Polynesia possibly explains their continuing conflict in the Chatham Islands [8].

In King's account Nunuku-whenua, sickened by the bloodshed and cannibalism arising from the conflict of two tribes, Rauru and Wheteina, fighting at Karewa on the western side of Te Whanga lagoon, pushed between the warring parties and ordered each side to retire:

> Stricken with stupefaction at this apparition, without striking another blow, they so retired. 'Follow me!' Palsied with a fear of the unknown, they followed. When they reached the shore he cried: 'You, Rauru, sit there; you, Wheteina, here!' They sat accordingly. 'Onlookers, gather all arms and stack them there!' Obediently the arms were stacked. 'Build a fire and cast the arms on top!' The fire was built, the spears and claymores of wood were burnt, yet no word was spoken in protest. 'Rauru! Wheteina! arise and meet!' They arose and met. 'Touch nose to nose!' Nose to nose was touched. 'Listen all! From now and forever, never again let there be war as this day has been! From today on forget the taste of human flesh! Are you fish that eat their young?'
>
> So it was there agreed that because men get angry and during such anger feel the will to strike, that so they may, but only with a rod the thickness of a thumb, and one stretch of the arms in length, and thrash away, but that on an abrasion of the hide, or first sign of blood, all should consider honour satisfied. 'And,' said the teller, 'all obeyed! Why? Because of the Nunuku curse: "May your bowels rot the day you disobey!"' [7].

European contact catapulted Moriori towards an extinction they had avoided for two and a half thousand years. The seal population on which they depended for clothing and food were clubbed to extinction perhaps in a generation by European sealers. Moriori themselves were ruthlessly and systematically slaughtered by Te Ati Awa who, on first learning of the existence of the Chatham Islands, commandeered a whaling ship and seized the Chathams from them, securing their conquest by slaughter and enslavement. The destruction of Moriori traditional culture and freedom brought despair and suffering as psychologically undermining as the physical abuse and servitude to which they were subjected. Their achievement in creating and maintaining a viable society for thousands of years in the isolation of the Chatham Islands was forgotten, their supposed primitiveness used to justify their continuing enslavement, even after British law governed the islands.

The story of Nunuku imposing a rule of non-violence on the medieval migrants is significant. This moral victory by indigenous Moriori probably secured the survival of the islanders down to the time of European contact. Though their uncompromising adherence of the Law of Nunuku in the face of Te Ati Awa invasion kept their mana intact, as the Moriori saw it, their refusal to fight the invaders branded them without mana in the eyes of their Maori conquerors. The Chatham Islanders' long cultural evolution, their sophisticated attunement to the ecology of the islands and to the fine balance needed for survival were wiped out by invasions of European sealers and whalers and by Maori with aggressive cultural prerogatives, both groups lacking understanding or appreciation of the culture and ecology they destroyed in passing.

20.7 Constructing a Chronology for Moriori Prehistory

The generation length for the Maikoua line can be estimated from the ancestor Rongomaiwhenua, in common with the Tamahiwaki line, in combination with the date of 1868 for the transmission of the genealogy to Shand: 2,672 years and 127 generations. This provides a mean generation length of 21.04 years for the Maikoua line, compared with 21.21 years for the Tamahiwaki line. The use of the Tamahiwaki generation length rather than the Maikoua for events prior to Rongomaiwhenua may appear biased. However, the difference is more apparent than real. The use of the Maikoua length generation puts Tangaroa-matahi at 1015 BC rather than 1018 BC and Tokoroa at 1373 BC in place of 1378 BC. Climate proxy corrections do not distinguish these very small differences.

Only two sets of colonists are recorded as arriving during the isolated prehistory of the Chatham Islands. The earlier of these was the migration led by Kahu. In the Tamahiwaki genealogy Kahu arrives 100 generations before 1868, in the Maikoua genealogy 102 generations before 1868. With a generation length for the Tamahiwaki line of 21.21 this gives a date of 254 BC. The Maikoua genealogy with a generation length of 21.04 gives a date of 279 BC, a variation of 25 years.

The second set of colonists arrived in the *Rangimata* and *Rangihoua* canoes during the Medieval Climatic Optimum. The Tamahiwaki line shows these canoes arriving 99 generations after the first settlement of the Chathams, giving a date of

AD 1295. The Maikoua line has them arriving 98 generations after the first settlement of the Chatham Islands and yields a date of AD 1258. These dates show reasonable agreement.

There is external evidence that enables us to offer a third estimate for this later colonization. As we saw in Section 20.3, Shand notes, probably from Moriori traditions, that Kahukura's nephew and niece migrated in the *Rangimata* and that the niece's husband actually built the canoe. From the Navigators' Line we have a date of 1230 for Kahukura, associated with a level 5 El Niño in 1230, which we linked to the migrations he led in tropical Polynesia. If we add a generation length from the main Rarotongan line, we get a date of about AD 1255 for the arrival of the *Rangimata* in the Chatham Islands. This exhibits excellent agreement with the Maikoua line estimate.

Tradition tells us that the voyage from Eastern Polynesia to the Chatham Islands was slow and perilous. The migrants arrived starving, suffering from thirst, so weak that they were unable to bring the *Rangihoua* safely to land, many drowning as the canoe broke up when the migrants tried to beach it [9].

Two and a half thousand years of almost unbroken isolation preserved the two Moriori genealogies that enable us to sketch a history for the Moriori of the Chatham Islands and to estimate from the genealogical record of their history a date not only for the first settlement of the Chatham Islands in about 805 BC but the first settlement of New Zealand in about 1378 BC. The latter estimate places the first settlement of New Zealand firmly in what is thought of as the age of Lapita colonization between 3,600 and 3,000 years ago. The Lake Huguang Maar climate proxy data locates the event about 1358 BC. This date suggests that New Zealand was seen as a prime colony, a first choice not an afterthought, and that it was probably settled before Western Polynesia. The warm East Australian Current sweeping past New Caledonia to the west coast of the South Island provided a fast ocean passage from New Caledonia that was little longer than the length of New Zealand itself. The high frequency of El Niño events 3,400 years ago noted by Anderson et al. could have provided the additional sailing support of a strong El Niño northerly.

20.8 The Early Prehistory of New Zealand

The early prehistory and palaeodemography of the Lapita-age colony in New Zealand was shaped by climate as surely as the later prehistory and palaeodemography of New Zealand during the Little Ice Age. A near-extinction event, linked to an early major eruption of Taupo and the descent at about this time of the coldest global period in 6,000 years, isolated New Zealand till the time of Tu-te-rangi-marama (360 BC). It did so at a time when its population was small and vulnerable to isolation. Ceilings of sustainability were not at issue. The population was too small to starve even if the biomass was greatly reduced by cold. It was isolation that threatened survival. Migration normally involves genetic bottlenecks and Polynesian migrations were tribal and kin-based. Genetic bottlenecks lead to faster coalescence, a faster loss of genetic diversity and greater risk from genetic disease and inbreeding. Possibilities for genetic adaptation are restricted by lack of diversity. The risk to founding populations whose numbers cannot but remain low for many generations is obvious. The possibility suggested in the Tamahiwaki traditions of threatened extinction with loss of fire underlines the very real hazards of isolation. It seems entirely probable that early descendants of the first New Zealand colonists and the perhaps accidental colonists in the Chatham Islands were both subject early in their prehistories to such risks. The Moriori genealogies provide a genealogically feasible date for a near extinction about 1018 BC. The Huguang Maar data, recording the most extreme event in 4,500 years, provides support for the suggestion that this event could correspond to a major eruption of Taupo which could indeed have caused a near-extinction event for the young New Zealand colony. As noted, both the genealogical estimate and the Huguang Maar proxy data estimate can be placed at the mid-point of the geological dating range (1200–800 BC).

That the original Spice Island first-wave colonists did, in fact, survive in New Zealand is recorded in the tradition of Maui the Navigator's visit. Their loss of technological skills – surely not as great as that of the Tasmanian Aborigines – angered Maui. Linguistic divergence was apparent. The Lapita descendants in New Zealand had presumably long since reinvented the art of fire-making, for Maui saw the fires of the "wild men of the woods" when he landed at Mahitahi (Bruce Bay) and noted cooking fires at the village of Orokoroko (Palliser Bay). Maui concluded nonetheless that the Lapita descendants were "moho", a backward or primitive people.

The isolation of New Zealand for over 600 years after a near-extinction event determined its genetic and technological history, as did the isolation of Tasmanians for over 5,000 years following the near-extinction event Flannery describes. In New Zealand isolation ensured that the strongest genetic elements in the makeup in the descendants of the first-wave Lapita-age colonists were derived from their Spice Island ancestors, not only for the first 1,500 years of their history but ever afterwards. No further colonists could reach New Zealand during the extreme cold period. The next visitors or colonists probably did not reach New Zealand until Tu-te-rangi-marama landed there, 1,000 years after the original Spice Island colonists. Our calculations suggest that even by AD 1180, at the beginning of the Medieval Climatic Optimum which saw Eastern Polynesian migrations to New Zealand, after another thousand years of sporadic migration, nearly all of the genetic makeup of the Maori would still have been determined by the original Spice Island migrants. Time, isolation, genetic bottlenecks and the laws of coalescence dictated this outcome.

It is perhaps surprising to readers to discover that memory of the forgotten early history of New Zealand is accessible through an approach as direct, simple and pragmatic as that of studying the two Moriori genealogies in conjunction with new climate proxy data. But the Moriori genealogies are not the only sources for the early prehistory of New Zealand. Traditions preserved in New Zealand supply corroborative detail, as we saw in Chapter 16 with accounts of the meeting of Maui the Navigator with the chieftainess at Orokoroko. In Herries Beattie's recounting of traditions relating to early migrations, he cites dozens of place names given by migrants, arriving after the end of the global cold period, to the places they explored [10]. The place names listed in our discussion of Maui the Navigator's visit to New Zealand in Chapter 16 are a good example of explorers celebrating their discoveries by naming prominent features of the land they are exploring, as are traditional accounts of the explorations of Rakaihautu and his party in the South Island of New Zealand. Place names frequently record the names and experiences of members of the exploring parties. The routes taken by those exploring the land are carefully recorded, their discoveries – mountains, lakes, rivers – named and by implication claimed.

20.9 Suggesting a Chronology for Some Early Migrations to New Zealand

The task of assigning dates to some of the early migrations recorded in tradition as reaching New Zealand is not easy. Genealogies may not reach back to founding events, may be limited in length, may not be connected to those of other areas or other canoe lines and may not be associated with events or persons who can be dated. Generation lengths may vary from area to area and over time. In some cases, where something is known of the history of a migrating canoe and of the subsequent history of the migrants it brought to New Zealand, there is hope of linking the migration event to climate proxy data. But in many cases, because we lack genealogical information, we cannot hope to make the needed correlations.

For early migrations to New Zealand for which there is some genealogical data (the basis for Beattie's chronological estimates [11]) the most convincing correlations of migrations with climate events involve extreme El Niño events, the pattern we have observed for significant voyaging events in Eastern Polynesia.

The date for Ui-te-Rangiora's voyage to New Zealand (AD 689), linked to a level 5+ El Niño and an associated El Niño cluster, can be compared with Beattie's suggested, genealogically derived, date of 650. A paired level 4 and level 5 El Niño give a date of 841/2 for Rakaihautu's migration (dated by Beattie to 825). For Kupe and Ngahue's voyage to New Zealand, which Beattie dates to AD 925, there is a choice between a level 5 El Niño in 903 and a level 5+ El Niño in 967.

We note that Beattie discusses three Kupes recorded in South Island traditions [12]. One Kupe he describes as "very early", one he dates to 1,300 and third he dates to 925. Beattie offers evidence that shows that the Kupe who voyaged to New Zealand with Ngahue in 925 knew of Maui's visit to New Zealand over 800 years before. He referred to New Zealand as *Tiritiri-o-te-moana* (Maui's name for the South Island).

Beattie's estimates for early migrations to New Zealand led by descendants of Maui, up to and including Rakaihautu, were based on genealogies preserved in the South Island. There are only small variations between his estimates, based on genealogical data, and estimates refined through correlations with climate proxy data. In each case the high-level El Niño events involved establish them as rare events, increasing their appropriateness for sharpening the genealogically based estimates and increasing the likelihood of the refinements made by this means. The rarity of the El Niño events, both in this context and in connection with the main Rarotongan line, in each case effectively determines the most likely estimate within the possible chronological bounds.

However, there appears to be little reliable genealogical information from within New Zealand to help date Eastern Polynesian migrations to New Zealand during the Medieval Climatic Optimum. We rely on Rarotongan genealogical data to date the voyage of Hoaki and Taukata to New Zealand in AD 1200. The migrations carrying Ngāti Ruanui and Ngā Rauru ancestors to New Zealand recorded in tradition can possibly be dated to the 1230 level 5 El Niño which we have correlated with Kahukura's migrations within Eastern Polynesia. A level 4 El Niño in 1244 may have triggered other migrations of these tribes. Ngāti Ruanui, for example, is associated with three migration canoes aside from several canoes of the *Heke* [13]. But without reliable generational estimates, which can reasonably be correlated with high-resolution climate proxy data, there is no reasonable guide as to which extreme climate events are likely to be involved. The dating margins proposed for the arrival in the Chatham Islands of the *Rangimata* and *Rangihoua* canoes of 1295 and 1258, based on the Moriori genealogies and of 1255 from the main Rarotongan line, which also carried Ngā Rauru peoples, suggest that earlier migrations to New Zealand may have preceded those to the Chathams. This may support the El Niño-based estimates we have suggested of 1230 and 1244 but the absence of reliable genealogical evidence in New Zealand prevents us making reliable correlations with climate events that can be easily dated.

Nevertheless, where reliable genealogical estimates are possible, the correlation of severe El Niño events with significant voyaging activity that we have seen in tropical Polynesia seems to hold both for dating earlier migrations to New Zealand led by descendants of Maui, probably from the Spice Island region or Western Polynesia, and for dating medieval Eastern Polynesian migrations to New Zealand using genealogical estimates from the main Rarotongan line. El Niño-driven drought, starvation and conflict are usually implicated in triggering such migrations.

Probably the most dramatic conclusion to emerge from combining genealogically based and climate-based dating estimates is the consistency with which throughout Pacific prehistory long-distance oceanic migrations and significant voyaging activity are correlated with rare extreme climate events. That the voyaging history of the Pacific is climate-modulated is an inevitable conclusion. Study of the demographic impact of the Little Ice Age on prehistoric Maori populations in New Zealand shows demographic history was also directly climate-modulated. Drought-triggered oceanic migrations occurred in response to demographic stress, which was in turn triggered by climate extremes or by the famine and conflict which were the consequences of these climate extremes. Such correlations encourage the mining of climate proxies for the chronological insights they can provide. In many cases the rarity of the climate (or volcanic) events recorded in proxy data makes correlations with events recorded in tradition likely and establishes associated dating estimates as robust.

20.10 Some Implications of Our Chronological Method and Results

Our method, which correlates Polynesian genealogical data with climate proxy data, might be seen as a marrying of science with tradition. Yet El Niño low Nile flood proxy data is not a product of modern science. Rather it lists ancient records of low Nile floods, which scientists interpret as proxy data for ancient El Niño events. The chronological method we employed for studying oceanic migration in the southern Pacific in the first millennium AD and in the Medieval Climatic Optimum in fact combines two ancient data sources, ancient Egyptian records on the one hand, ancient Polynesian genealogical records on the other. Whether preserved as written records or preserved orally and later transcribed, the historical value of both sets of these ancient records is obvious.

The Huguang Maar data, on the other hand, is a direct result of modern scientific research (analysis of titanium concentrations and magnetic susceptibility in lake sediments). Like the El Niño low Nile flood proxy data, it confirms the closeness of generational estimates from carefully preserved long genealogies to scientifically and independently established climate estimates. The consilience of results from such different sources confirms the value of traditions and of the genealogies on which dating estimates for events in tradition largely depend. Climate proxy data clearly provides a useful tool for sharpening the genealogical estimates, whose relative variability is a mark of their authenticity. Just how little these genealogical estimates need to be sharpened is to some extent a measure of how accurately traditional knowledge is recorded in the best, most carefully preserved, genealogies and on the relative constancy of their mean generation lengths (a factor that we have suggested was to a large extent ensured for the Moriori genealogies by the maintenance in the Chatham Islands of a controlled population size over a long time span).

Traditional histories, secured to genealogies, underpinned by dozens of place names assigned by migrants and preserved over long stretches of time, have been largely ignored by archaeologists in the last 50 years. Invaders and conquerors characteristically rewrite history. Often they obliterated the earlier histories of the conquered peoples and imposed their own history on them or manipulated such records for their own purposes. Uncharacteristically, early European prehistorians in New Zealand tried to preserve indigenous history. Recent scholarship, however, has reversed this conserving approach. Late settlement theorists deny 2,600 years of indigenous history in claiming that New Zealand had no history prior to AD 1200. It is hardly surprising that the demography they suggest for New Zealand fails to match either the archaeological (pa) evidence or the evidence from traditional histories.

Rakaihautu – whose migration we suggest occurred in AD 841/2 – sailing down the east coast of the North Island is said to have found the North Island already fully occupied. He decided to explore and settle in the South Island instead. In Section 15.2 we estimated a population growth rate of 0.307% from 1358 BC to AD 1445 for the pa areas of the North Island. With the estimate of a founder population of 289, this supplies an estimated population for the north of the North Island in AD 841 of just over a quarter of a million. If we take the non-pa population in 1445 as 36% of the total population of the North Island (a figure matching 10,000 survivors in 1801), the corresponding total population for the North Island in AD 841 would be just under 400,000. Given this estimate, it is hardly surprising that, as tradition tells us, Rakaihautu decided that the North Island was fully settled.

Though conveniently ignored by late settlement theorists, the recording of early significant populations challenges current assumptions. As does the record from tradition that at the time of the *Heke* there were 22 tribal divisions claiming descent from Toi, whose people had intermarried with the tangata whenua of Whakatane and nearby districts [14]. The title "Tini o Toi", the great multitude of Toi, said to have been "swarming like ants", makes more sense, given our demographic estimate of 1,561,000 for the total pa population in 1445 than could any possible population estimate based on a time depth of only 200 years. Tradition supports our claims from demographic analysis both for a very significant time depth for settlement and for high populations at the beginning of the Little Ice Age. As we have seen, high populations at this time are a corollary to the climate-driven negative demographic parameters that we showed in Chapter 15 led to an effective loss by 1801 of 92–93% of the North Island population of 1445.

That there was a sizeable population in New Zealand by the time of Rakaihautu is clear not only from subsequent levels of population loss but also from evidence of early pa-building. Tradition records, for example, that the Ope-ruaraki people, who may have arrived in about AD 713 in the Te Ara-tau-whaiti canoe under Taiehu, "as a means of protection against the people already in the country built a stockade or pa which they named Ritua" [11]. Toi's pa in Whakatane, Kapu-te-Rangi, was presumably also a migrant people's defence against the large numbers of indigenous people in the area in which he settled.

Matching archaeological evidence to traditional history has always been a problem in New Zealand, largely because New Zealand lacks readily datable artefacts from which to construct cultural sequences. The vexed question of admissible radiocarbon dates has compounded problems of interpretation as well as of chronology. Our attempt in Part II to study archaeological evidence implicit in Maori pa, of all artefacts the hardest to ignore, and especially to analyse the demographic implications of the pa evidence, belongs to a more comprehensive attempt to match traditional history with archaeological evidence and climate history. Evidence for sharply falling populations by 1445 reveals demographic patterns, at odds with current historical interpretations, but very much in accord with traditional histories and climate research.

Our analysis in this chapter of the ancient genealogies preserved in the Chatham Islands shows the potential inherent in preserved traditions for illuminating the early settlement history of New Zealand and of the Pacific. Prehistory, as we suggested in the Introduction, depends on a consilience of evidence from many disciplines. We have suggested how the insights archaeology provides can be complemented by using ancient records and oral traditions to illuminate prehistory and by exploiting the enabling power of mathematics and science and the chronological precision of climate proxy data. In keeping with our pleas for a wider, more inclusive approach to oceanic prehistory, we turn now from a reading of ancient genealogies to the modern discipline of genetics to conclude our case for a Lapita-age first settlement of New Zealand.

20.11 Low Maori Genetic Diversity

Maori has the lowest genetic diversity of any Polynesians and very low genetic diversity by any standard. Geneticists tailoring their interpretations of New Zealand genetic history to accord with current archaeological thinking (New Zealand considered as having at most a history of 800 years) cite as the cause for the low genetic diversity of Maori the accretion of genetic bottlenecks through a cumulative sequence of migrations (from Near to Remote Oceania to Western Polynesia to Eastern Polynesia to New Zealand). Thought to represent the last migrations to have taken place in the Pacific, the populations of New Zealand, Hawaii and Easter Island at the three apices of the "Polynesian triangle" are seen as being "at the end of chains of migration" [15].

The paradigm implicit in this theory is one of logical stepwise, west–east conquest of the Pacific. Because it is thought to have been settled last, New Zealand especially is seen as a terminus on a branch-line that followed innumerable mainline migrations from Western Polynesia to Eastern Polynesia.

This theory of course presumes a late solely Eastern Polynesian origin for Maori – a presumption contradicted by tradition and by the evidence that we have presented in this book. The "chains of migration" explanation for low Maori genetic diversity is confounded by the possibility that New Zealand was settled at least 1,000 and possibly as much as 1,900 years before Eastern Polynesia.

There are alternative explanations for the low genetic diversity of Maori.

In this chapter we have considered the possibility of a near-extinction event in early New Zealand prehistory. A near-extinction event, of course, has major implications for loss of genetic diversity. In 1027 BC New Zealand would have had a population of about 797 (a figure arrived at by using the power law estimate for population growth and a founder population of 289). If this population were halved through some catastrophe, it would be reduced to less than the minimum of 500 Flannery cites as necessary to guarantee long-term survival. Just as serious would be the associated loss of genetic diversity, though given the colonists were kin-based to begin with, it would be hard to estimate the extent of the loss. Certainly, coalescence would be speeded up, perhaps many or most of the rarest haplotypes would have been lost at the time of the catastrophe, with the most common haplotypes multiplying more quickly thereafter.

Such an event occurring just over 300 years after first settlement would have had a controlling effect on the ultimate genetic outcome. As coalescence proceeded, there would be a continual lessening of genetic diversity, especially when for 600 years climate isolated the peoples in New Zealand, preventing the possibility of new genes arriving with new migrants or visitors.

Here we can contrast the pattern in New Zealand with that in tropical Polynesia, which had a far shorter history and so a shorter time for coalescence to occur. In Eastern Polynesia, given shorter distances between archipelagoes, warmer sea surface temperatures, El Niño westerlies and seasonal westerlies to aid voyaging, greater genetic diversity can be seen as a product of greater general voyaging activity, easier accessibility to other archipelagoes, greater trading opportunities and cultural co-operation (as seen, for example, in the practice of seeking distant wives for chiefs' sons). Kin-based migrations within Polynesia would have limited initial genetic diversity but over time the tropical Polynesian islands would have been exposed to continual infusion of new genetic material from migrants and visitors. In New Zealand we have a very different pattern. The consequences of an initial genetic bottleneck in limiting genetic diversity would have been compounded by catastrophic loss of population in an early near-extinction event. The long period of isolation that followed would have excluded the descendants of the original Spice Island colonists from any infusion of new genes.

As we have seen, tradition reports a large population in the North Island in about AD 841 at the time of Rakaihautu. Our demographic estimate of a population just under 400,000 confirms this. Because of the size of the population in 841, later infusions of genes through sporadic migrations would have contributed little, percentage wise, to the Lapita base: in other words, as descendants of the Lapita-age original settlement increased in numbers, additional migrations would take appreciable time to increase genetic diversity.

Earlier migrations would have been more significant. The visit in 360 BC of Tu-te-rangi-marama and his and his crew's contribution to the gene pool both in New Zealand and in the Chatham Islands must have been welcome. Over 450 years later the canoes led by Maui reached New Zealand, as did the canoes of Maui's defeated enemy and of his friend Tiwakawaka, who followed Maui to New Zealand. The crews of all of these canoes probably contributed to the genetic diversity of the tangata whenua. The people of Kui whom Maui left in New Zealand to defend his land rights, the migrations led by Maui's son Wi-Wi and Wi-Wi's great-grandson Tutumaiao will also have added diversity to the gene pool. In AD 1180, at the beginning of the Medieval Climatic Optimum, through coalescence, nearly all Maori who had at least one ancestor in New Zealand at the time of Maui would have had a common set of ancestors who were part of the first settlement.

While we think the later migrations led by the Tiwakawaka who may have arrived in about AD 850, Kiwa, and the immigrants left by Kupe to have been early, none of these were early enough for coalescence to have occurred by the beginning of the Medieval Climatic Optimum or indeed for them to have made significant contributions to the Maori gene pool by this stage, even though all these early migrants would have intermarried with indigenous tribes for protection and to obtain land rights. Nearly all of the genetic contribution to the gene pool at the beginning of the Medieval Climatic Optimum would have been from the founding first-wave Spice Island colonists.

We have noted that a power law estimate of a founder population of 289 is a size in accord with the traditional practice of using fleets to found colonies. The practice, mentioned from earliest times in oral records, clearly persisted down to the *Heke*. The survival – physical, genetic and cultural – of a Lapita-age Spice Island colony in New Zealand may well have depended on this practice of providing a significant founder population, given both the long climate-imposed isolation of the colony early in its history and the near-extinction event recorded in Moriori tradition. Even though kin-based, a large founder population would have provided greater initial genetic diversity, making survival of a near-extinction event more likely and helping to counteract faster coalescence caused by extended early isolation which prevented the possibility of new genetic input for more than 600 years. That the original Spice Island colony survived for 1,500 years, despite an early extinction event and a long climate-enforced isolation, suggests that it was a large, well-organized migration with a significant founder population (as archaeological evidence shows most Lapita-age colonizations to have been).

The major loss of genetic diversity through an early near-extinction event might alone account for most of the low genetic diversity of Maori. But this early loss would have been compounded by the catastrophic population losses in New Zealand during the Little Ice Age and from AD 1800 to AD 1896 following European contact. The factors favouring higher genetic diversity in Eastern Polynesia and the factors explaining limited genetic diversity in New Zealand are specific to each region. Genetic outcomes for both can be seen as a consequence of the relative time depths of settlement and of their own genetic and demographic histories.

And yet, although a very considerable time depth in New Zealand would allow for increased coalescence and so loss of genetic diversity, it would also allow for the generation of genetic diversity through mutation. The four rare Maori haplotypes discovered by Whyte, Marshall and Chambers [16], two of which are fast-evolving and one of which is stated to have only a 33 generation mutation time, can be explained as indigenous mutations, dispersed through coalescence into the genetic matrix of New Zealand Maori. The contrast between Eastern Polynesian and Maori haplotypes contradicts the claim that Eastern Polynesia was the sole source for Maori genes. Of the 24 Eastern Polynesian haplotypes, New Zealand has only four and of these only one is uniquely shared with Eastern Polynesia. Of the four held in common three are also shared with Western Polynesia and two with Melanesia. Four haplotypes out of nine appear to be indigenous, unique to Maori, unknown elsewhere in Oceania. A long prehistory in New Zealand allows time for these haplotypes to represent indigenous mutations. Because migration was one way, from Eastern Polynesia to New Zealand, these unique Maori mutations could not have been shared with other parts of Polynesia.

Low genetic diversity in New Zealand Maori can be seen as additional supporting evidence for the long prehistory we claim for New Zealand, for climate-determined isolation both after 1000 BC and after the descent of the Little Ice Age, for significant population by the beginning of the Medieval Climatic Optimum and massive depopulation during the Little Ice Age and following European contact. The isolation of New Zealand and of the Chatham Islands created unique prehistories for their indigenous peoples. Modern demographic analysis brings new clarity, indeed supplies an entirely new reading of the early prehistory of New Zealand. It is clear that New Zealand's demography was climate-driven. Climate was a controlling factor, whether dictating isolation or again making long-distance voyaging feasible, whether supporting larger populations through horticulture in the Medieval Climatic Optimum or reducing feasible growing areas in the Little Ice Age and exposing some of those populations to starvation. One of the major points we make in this book is that understanding the prehistory, palaeodemography and genetic history of New Zealand is scarcely possible without appreciating the fundamental role of climate in shaping all three.

Understanding the early prehistory of the Pacific requires acknowledgment of the oceanographic base of Spice Island maritime history (following three of the four major currents flowing out of the West Pacific Warm Pool into colder oceans) and of its triple maritime focus in exploration, trading and migration. It requires recognition of the Spice Island origins of first- and/or second-wave migrations to Madagascar, Japan, New Zealand and Hawaii and contact with America before the global cold period in 1000 BC and recognition of a Lapita-age first settlement for New Zealand. Recognition of the long prehistory of New Zealand and the Chatham Islands confirms our central paradigm. The evidence we have gathered to establish a Lapita-age first settlement of New Zealand strengthens the fundamental claims of the book: that first- and second-wave Spice Island migrants established early settlements on the major uninhabited islands in two oceans that could be reached by following West Pacific Warm Pool currents and that first- and second-wave Spice Island explorers and traders followed these currents to their continental limits in two oceans.

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Chapter 21
A Consilience of Evidence

Abstract Evidence of many kinds has been assembled in the course of the book in support of the central paradigm that the Spice Island ancestors of the Polynesian peoples followed three major currents flowing out of the West Pacific Warm Pool to their limits in two oceans and that they did so before 1000 BC when a global cold period halted transoceanic voyaging for 600 years. We show that their descendants after 400 BC, adopting the same sailing and exploration strategies, re-established the remarkable range and scale of their ancestors' transoceanic exploration, trading and migration. In this final chapter we offer an overview of the evidence gathered in support of this paradigm. And we reflect on the methodology employed to create a synthesis of insights from diverse sources. As the title of the book proclaims, empowering this synthesis is a recognition of the fundamental roles of oceanography and of global climate change in determining the paths, sequence, timing and range of prehistoric migration in the Pacific and Indian Oceans.

Keywords Overview · Polynesian prehistory · Oceanographic base · Climate-driven demography/migration · Climate change · Consilience of evidence

Maori and Moriori traditions offer tantalizing glimpses of ancient forgotten events, fragments from a past now lost beyond recall. Mention of the loss of fire, possibly evidence of an ancient near-extinction event, is tied to the name of an ancestor who lived 17 generations after the first settlement of New Zealand. Surprising details from accounts of Maui's meeting with the chieftainess of Orokoroko hint of a long isolated past in New Zealand for the people that Maui met there and dismissed as stupid and backward. Awareness of the ancient form of Creation myths preserved in the Chatham Islands offers subtle and indirect evidence of Lapita-age Spice Island descent for the Moriori. Two Moriori genealogies, by their very length and interpretative detail, appear to substantiate this claim.

Cumulatively such subtle and indirect evidence fleshes out more solid demographic evidence that belongs to the contexts of modern statistics, mathematics and demography and that as insistently proclaims that Maori had a history in New Zealand long enough to reach back to Lapita times.

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We have assembled evidence of many kinds in the course of the book in support of our central paradigm that the Spice Island ancestors of the Polynesian peoples followed major currents flowing out of the West Pacific Warm Pool to their continental limits in two oceans and that they did so before 1000 BC when a global cold period halted transoceanic voyaging for 600 years. We show that their descendants after 400 BC, adopting the same sailing and exploration strategies as their ancestors, re-established the remarkable range and scale of their ancestors' transoceanic exploration, trading and migration. In this final chapter we offer an overview of the evidence gathered in support of this paradigm. And we reflect on the unusual methodology employed to create a synthesis of insights from diverse sources. As the title of our book proclaims, empowering this synthesis is the recognition of the fundamental roles of oceanography and of global climate events in determining the paths, sequence, timing and range of prehistoric migration in the Pacific and Indian Oceans.

Remarkably a suggested Lapita-age first settlement for New Zealand follows from the logical and pragmatic exploration and sailing strategies adopted by Spice Island mariners in the earliest phase of the peopling of the Pacific. In hindsight we can see that these choices were determined by their need to confront the greatest risk facing them, first as long-distance maritime traders and then as explorers and colonizers of the Pacific: the risk of hypothermia. We argue in Part I that the maritime and genetic background of the Spice Islanders was shaped by their need to avoid or minimize hypothermia. For the first 30,000 years of their maritime history, sailing on rafts, they would have been exposed to cumulative selective pressure to develop genetic resistance to hypothermia. Studying the unique geography, history, horticulture and economics of their homeland reveals how it prepared Spice Islanders, as horticulturalists and mariners, to become colonizers of the Pacific. Their genetic evolution of cold resistance and famine resistance, through tens of thousands of years of natural selection in the Spice Islands, and their exploiting of strong warm currents flowing out of the West Pacific Warm Pool made it physiologically possible for them to become explorers, horticultural traders and colonizers in two oceans.

Our focus on the historical implications of a Polynesian homeland located in the Spice Islands reveals a 40,000-year prehistory for the Lapita and Polynesian peoples that has not previously been explored. We present the maritime history of the Polynesian peoples as, in a very real sense, a continuation of the maritime history of their Spice Island ancestors. And we show that the exploration and settlement of the Pacific, viewed as part of that far longer history, possesses a compelling logic and coherence.

This is especially clear from the central paradigm we propose. This paradigm is rooted both in the physiological need to avoid hypothermia and also in the oceanographic nature and function of the West Pacific Warm Pool which, by means of four strong currents, drives warm water into the Pacific and Indian Oceans. It is rooted too in a cultural readiness to exploit new circumstances and new opportunities, a constant theme in traditional histories. We have shown how the remarkable volcanic heating of the West Pacific Warm Pool after the last Ice Age flood created new voyaging possibilities for Spice Island mariners. As we have seen, these new voyaging possibilities arose both from the warmer conditions of the Holocene and the increased warmth and range of the West Pacific Warm Pool currents after the drowning of Sundaland, and the separation of Australia and New Guinea, triggered undersea tectonic activity that led to higher sea surfaces in the Pool and opened up new patterns of flow. The volcanic heating of the Pool gave greater protection from hypothermia, both directly and through its currents, offering a voyaging speed that made it possible for mariners to sail longer ocean distances without landfall. Spice Island post-flood maritime prehistory gives evidence of a growing mastery of new skills and technologies which led to exploiting new voyaging and trading possibilities, both within the Warm Pool and beyond. The development of the stable double-outrigger, for example, made it possible both to exploit fast currents safely and to sail with a following wind, facilitating the transference into colder oceans of the long-distance voyaging skills learned, we suggest, in a West Pacific Warm Pool voyaging nursery.

Because of volcanic underwater activity in the West Pacific Warm Pool following the last Ice Age flood, it seems possible that the major currents flowing out of the West Pacific Warm Pool, in the period of first-wave exploration and settlement, and possibly in the second, may have been faster and warmer than they are today. Our paradigm predicts that, for Spice Islanders in both these periods, three of the four major currents flowing out of the West Pacific Warm Pool would have become ocean highways: trading and migration paths through two oceans. A consilience of evidence involving economics, palaeo-oceanography, archaeology, genetics, field archaeology and palaeodemography, evidence of cultural diffusion and linguistic differentiation, and evidence from oral histories shows that the migration paths predicted by our paradigm were followed in both periods. Following three of these four major currents, Spice Islanders were carried north through the West Pacific Warm Pool through Micronesia to Japan and then east from Japan to Hawaii and America with a landfall in southern California; south to Java and then west to Madagascar and the east coast of Africa; south through Island Melanesia and along the east coast of Australia till a diverging part of the current led them to a landfall on the west coast of the South Island of New Zealand. We have shown how a chosen exploration strategy of following these fast warm currents would have made rapid and extensive expansion possible before the global cold period in about 1000 BC halted long-distance voyaging for 600 years. Inherent too in our paradigm is the prediction that, when warm global conditions returned after 400 BC, Spice Island explorers, traders and colonists would have followed the same warm currents across the same vast ocean distances to the same destinations and the same landfalls.

Our paradigm not only successfully predicts the likely paths for both a first and second wave of exploration and settlement but reveals the continuity of the Spice Island maritime culture in Island Southeast Asia 25 generations after the Lapita exodus to Near Oceania, Island Melanesia and Western Polynesia. We suggest that awareness of this continuity has been lost through concentration on the history of the Lapita peoples, conceived of as having a late Taiwanese rather than an ancient indigenous Spice Island origin, and lost through concentration on Western

Polynesia, which has been regarded as the only base for expansion when warm conditions returned.

Physiology and oceanography suggest a different early history for the Spice Island ancestors of the Polynesians. To counter the risk of hypothermia on long-distance voyages Spice Island mariners needed to ensure the fastest possible passage. Their best option as explorers and colonizers was to exploit strong warm currents flowing out of the West Pacific Warm Pool; to undertake long voyages only in warm global periods when sea surface temperatures were high; to avoid west–east sailing against the trade winds and currents of the southern Pacific; to exploit following winds (monsoonal winds in the Indian Ocean and El Niño northerlies when following the East Australian Current south to New Zealand); and when possible to sail at the onset of an El Niño event when SSTs were at their warmest.

The patterns for exploration, trading and settlement in the Pacific and southern Indian Oceans predicted by our paradigm possess a logic dictated by human physiology (the need to counter hypothermia); dictated by the persistent economic motivation of spice trading and later conceivably of rare plant trading; dictated by the geography and maritime history of the Spice Islands (located within or close to the boundaries of the West Pacific Warm Pool); and dictated by the oceanographic nature and function of the West Pacific Warm Pool and of its outflowing currents. The sailing and exploration strategies learnt by Spice Island mariners in what we have described as their West Pacific Warm Pool long-distance voyaging nursery and transferred into two cooler oceans dictated the exploration paths the Spice Islanders would follow and thus the lands they would first discover and settle.

Our conception of Polynesian prehistory is transformed by recognition of the oceanographic significance of the West Pacific Warm Pool and of its role in shaping the history of oceanic migration. The paths, sequence, timing and range of oceanic migrations were determined by the choice of three of its four major currents as ocean highways. Migration paths were determined by the paths of the currents themselves, the range of these paths determined by the currents' continental limits.

Sequence and timing are more difficult to unravel. Spice trading was probably an early driving factor. We have suggested that a trading route to Japan may have been earliest, the settlement of Palau nearly 6,000 years ago a conceivable indicator for the establishment of such a route. But possibly 2,000 years separates a conjectured early route to Japan from the establishment of the Cinnamon Route. The difference in the skills required to sail the latter suggests a considerable time lag. In place of the much shorter distance to Japan and a voyage almost wholly within the protective warmth of the West Pacific Warm Pool, with multiple potential landfalls in Micronesia, the Cinnamon Route required the transference of skills into a colder ocean. It required crossing an ocean stretch of almost 4,000 km without landfall, a distance equivalent to the total distance from the Spice Islands to Japan. The islands of Japan had long been inhabited. Madagascar and New Zealand were more enticing to migrants: they offered settlers the largest uninhabited islands in the Pacific and Indian Oceans that could be reached by fast ocean currents flowing out from the West Pacific Warm Pool. Migration to New Zealand involved sailing a distance more than twice that from the Spice Islands to Japan, though only two-thirds that from the

Spice Islands to east Africa. Migrations to New Zealand as to Madagascar required the transference of skills from the West Pacific Warm Pool into colder waters.

Demographic evidence for an early settlement of New Zealand based on field archaeology, world climate history and Moriori genealogies gives an estimate close to 1400 BC for the first settlement of New Zealand. Historians have linked the establishment of the Cinnamon Route to the demand in the reign of Queen Hatshepsut of Egypt for embalming spices which grew in the Spice Islands. We have pointed out a hiatus in sailing the route between 1000 BC and 400 BC which limits first settlement in both Madagascar and New Zealand to before or after the global cold period. Archaeological evidence establishes that Spice Island explorers reached America before 1000 BC and again after 400 BC. Traditional histories record both first- and second-wave migrations to Hawaii. The transoceanic distances from the Spice Islands to east Africa and southern California are similar, the likelihood that the Cinnamon Route was sailed before 1000 BC, given the spice-trading impetus, considerable.

The predictable pattern of ocean currents, determined by the Coriolis effect, dictated early exploration, trading and migration paths. It also dictated the Spice Islanders' exploration range and their technique for discovering new lands. We have shown that an exploration strategy based on knowledge of how ocean currents behave in the presence of a landmass would have led to the easy discovery of the largest islands in the Pacific and Indian Oceans. That the largest and best uninhabited islands would have been colonized first regardless of distance logically follows, given that there were fast warm currents to carry colonists to them. It is hardly surprising that this migration sequence accords with a leap-frogging migration strategy shown to have been the pattern worldwide for major post-glacial land migrations. And not surprising that, as on land, smaller and inferior lands, such as those in Eastern Polynesia, would logically have been settled much later, given that there were no convenient currents to carry migrants to them from the Spice Islands.

In Part I we present a consilience of evidence from many sources, both scientific and traditional, that cumulatively validate the fulfilment of the predictions inherent in our central paradigm: that Spice Island mariners would have followed three of the four major currents flowing out of the West Pacific Warm Pool to their limits in two oceans. And that they would have done so in two periods separated by the global cold period from 1000 BC to 400 BC.

Science provides us with robust evidence for the validity of what many may regard as the most extreme of these predictions: that Spice Islanders would have followed the Kuro Shio Current as far as America before 1000 BC. Sorenson and Johannessen's evidence points to a range and frequency of transpacific voyaging that could scarcely have been envisaged before they brought together scientific evidence from two evidence domains, botany and archaeology, to establish that 40 American plants were introduced to India between 1600 BC and about AD 1000. Genetic evidence from the study of a Polynesian commensal animal, *Rattus exulans*, shows that Halmahera was the ancient Polynesian homeland and so invites study of Pacific prehistory with a Spice Island base. Appreciation of the physiological research of Houghton relating to cold adaptation, combined with awareness of the oceanographic functions of the West Pacific Warm Pool, leads naturally to a recognition of the maritime significance of the high SSTs within the Pool for Spice Island traders during the Ice Age and into the Holocene and encourages recognition of the later importance for Spice Island maritime history of the role of its major currents in creating warm ocean highways through colder oceans. As evidence from these scientific disciplines is collated, the fundamental importance of the oceanographic history of the West Pacific Warm Pool in shaping Spice Island maritime history becomes clear. Studying traditional histories recording migrations to Hawaii and New Zealand, in the light of the oceanographic history of the West Pacific Warm Pool and of the patterned behaviour of currents due to the Coriolis effect, shows the scientific feasibility of the migrations that traditional histories record. Instead of being read as descriptions of mythical events, these histories can be recognized as documenting the maritime leap from the Spice Islanders' oceanic voyaging within the West Pacific Warm Pool to transoceanic voyaging beyond.

Following two of the fast warm currents flowing out of the West Pacific Warm Pool gave Spice Islanders significant trading advantages. Following the Equatorial Current through the Indian Ocean gave them fast access via east Africa to spice markets in the Middle East and Europe. Conceivably, following the Kuro Shio Current into the northern Pacific gave them very early access to a spice market in Japan and possibly through Japan with coastal China. Following the Kuro Shio Current all the way to America may have made it possible for both first- and second-wave Spice Island mariners to pursue the rare plant trade to India that Sorenson and Johannessen's evidence documents as spanning 2,600 years (punctuated by the 600-year gap of the global cold period). The economic motivation of horticultural trading can be seen to have driven Spice Island trading history for 40,000 years. There is a compelling logic in a Spice Island-based history with economics, physiology, genetics, botany, oceanography and climate history shaping that history.

Mathematics is a context largely unexploited by archaeologists and prehistorians. Part II brings a mathematical perspective to two major archaeological issues in the prehistory of New Zealand: the date for first settlement and the discrepancies between the numbers, size and apparent population capacity of pa and the low population estimates for Maori at European contact. Combining a reading of the prehistory of New Zealand in the context of global climate change with modern statistical analysis of skeletal data, of pa data from field archaeology and of power law estimates for founder population size and for population growth rates from first settlement to AD 1445 leads to a rewriting of New Zealand palaeodemography. The demographic patterns obtained by these means point to a greater time depth for first settlement than is currently envisaged. Indeed, through an analysis of two ancient genealogies preserved in the isolated Chatham Islands in Part III, we show that the date for first settlement stretches back, as our paradigm predicts, to Lapita times.

The prehistory of New Zealand requires an understanding of the many combining factors that have determined its course. It requires too an awareness of the many contexts in which evidence, explicit and implicit, can be sought and interpreted. This approach offers protection from the simplifications that can arise from too limited a focus. We have attempted throughout the book to demonstrate the value of oral traditions in enriching as well as unravelling prehistory. In Part III our study of the genealogies that underpin Polynesian traditional histories enables us to sketch a long chronology for Pacific prehistory. This chronology, and the reservoir of traditional histories it is drawn from, complements the archaeological context, in which history is read from artefacts, with contexts that involve a more traditional focus – a focus which includes awareness of the personalities of the ancestors who helped shape traditional history and of the tales that recount their voyaging exploits.

Traditional histories and the genealogies that underpin them have enabled us to sketch a long chronology for New Zealand prehistory in the apparent absence of securely dated archaeological evidence. With the earliest settlements buried by the successive erosion events Grant describes, with evidence of major coastal erosion from recurrent New Zealand-wide tsunamis, with no radiocarbon dates before the 12th century regarded as acceptable by some archaeologists, we have had to turn to subtler sources of evidence for an early first settlement of New Zealand. We have had to call on contexts such as genetics and mythology and point to the preservation of ancient (Lapita-age) totemic myths which were vestigially present in New Zealand but well preserved in the Chatham Islands. Yet underpinning these rarer contexts and subtler sources of evidence is evidence from another context: the irrefutable demographic evidence implicit in those most remarkable of Maori artefacts, the 7,000 pa that protected the horticultural landscapes of New Zealand. We have offered a new reading of these artefacts in the context of falling populations, seen as part of a worldwide pattern of climate-driven population loss in the Little Ice Age. A context of climate-driven demography is shown to be centrally relevant to an understanding of New Zealand palaeodemography and of the three and a half thousand year time depth which study of this palaeodemography reveals.

A Lapita-age colonization of New Zealand challenges the view of New Zealand as the most remote land in the Pacific which was logically settled last. Instead, in the light of our paradigm, the settlement of New Zealand is seen as belonging to and playing a significant part in the peopling of the Pacific in the 2,000-year-long period during which the Spice Islands, not Western or Eastern Polynesia, were the base for Polynesian expansion.

In Part II, we study Pacific prehistory in the context of global climate history – a focus that brings new insight to analysis. We use evidence for global climate change in combination with mathematics to study the impact of global climate extremes on demography in prehistoric New Zealand. This opens the way to a different view of Maori prehistory in the past 900 years. Our revision of an existing demographic study, based on skeletal evidence, and additional evidence from field archaeology, results in our being able to demonstrate a catastrophic population loss during the Little Ice Age of the order of 93% for Maori from AD 1445 to AD 1800. Highlighting the catastrophic consequences of global climate change impacting on ecology, we are able to show, through evidence of starvation and associated conflict over land and resources, the human consequences of extreme climate change in prehistoric New Zealand. We demonstrate the same patterns of climate-driven starvation, conflict and enforced migration in tropical Polynesia and worldwide wherever resource ceilings, lowered through the impact of climate extremes, were breached.

There has been a concerted effort by modern prehistorians to “de-Smith” Pacific prehistory, to disparage the work of early Pacific prehistorians from the late 19th and early 20th centuries, such as S. Percy Smith, Abraham Fornander and Edward Tregear, who also constructed chronologies for Pacific prehistory based on Polynesian genealogies. The climate-anchored chronology for Pacific prehistory that we sketch to some extent validates the chronologies of the early Pacific prehistorians and reasserts the importance of oral traditions as historical sources. It brings new clarity to the study of Pacific prehistory which in the last 50 years has been hampered in its attempts to construct a robust chronology by the lack of preserved and datable artefacts and controversies surrounding radiocarbon dating.

In the last section of the book, as part of our task of sketching a chronology for Pacific prehistory, we argue for the historicity of the last great migration to New Zealand. Thirty years ago this migration, popularly known as the *Heke* and once taught as history to every New Zealand schoolchild, was dismissed as a white man’s myth by David Simmons. Combining evidence from new and old contexts, we challenge Simmons’ dismissal of this migration as myth. We use statistical methods to disprove Simmons’ claims that the canoes of the *Heke* were not even contemporaneous. To disprove Simmons’ claims that New Zealand traditions about the canoes of the *Heke* referred only to internal migrations within New Zealand, we analyse the conflict over land and resources in Tahiti that prompted the last great migration and was recorded in Rarotongan and Maori tradition. We then use El Niño events and a solar eclipse recorded in tradition to date the last migration to New Zealand, demonstrating the potential value of the *Heke* traditions as historical sources and providing an anchor point for the climate-linked chronology we define in Chapter 19.

Perhaps most importantly Part III shows the role of extreme climate events, some with a Pacific-wide impact, in shaping Pacific history. Specifically in Part III we show the correlations of such events with major migrations, from the first migration to New Zealand nearly 3,400 years ago to the last migration to New Zealand in AD 1403. From the second half of the first millennium AD to the end of the Medieval Climatic Optimum (the period covered by the El Niño low Nile flood proxy data, which has an annual resolution), it has been possible to date some major migrations and long-distance voyaging activity to within a year. For dating significant events in early New Zealand and Moriori prehistory, we have been able to use a second climate proxy with a greater time range, created through analysis of titanium concentrations and magnetic susceptibility in sediment from Lake Huguang Maar in southeastern coastal China. With this high-resolution climate proxy data we are able to show that the early history of oceanic migration, not covered by the El Niño low Nile proxy data, was as clearly climate-driven as migrations in later periods. We are able to show that over a span of close to 3,000 years long-distance oceanic migration and significant voyaging activity can be correlated with rare extreme climate events, often events with Pacific-wide impact.

The value of both climate proxies, of low Nile flood data and of the Lake Huguang Maar data, rests on their high resolution. Extreme El Niño events can be dated from the record of low Nile floods to within a year. The scientists responsible for the Lake Huguang Marr data claim it has a resolution almost as sharp. The juxtaposition of long, carefully preserved Polynesian lineages with records of major climate and volcanic events from independent proxy sources, provides a chronological clarity for Polynesian prehistory not previously possible.

It is clear that a persistent pattern links early and late long-distance Spice Island and Polynesian oceanic migrations to rare extreme climate events. Sometimes migrations for the defeated and starving were triggered by El Niño-driven drought with associated famine and conflict or triggered by southward shifts in the intertropical convergence zone, which can be measured through titanium concentrations in the sediment of Lake Huguang Maar. Perhaps at times reversals in trade winds and currents, higher SSTs and in some cases specific wind support may have been recognized as creating optimal oceanographic and climatic conditions for long-distance exploration, trading or migration. The combination of climate-driven motivation, and sometimes of El Niño voyaging support, may explain the persistent links we see from the study of climate proxies between major oceanic migrations and extreme El Niño events.

Proxy climate data made accessible in recent years has made it possible to recognize this pattern. The high resolution of the climate proxies we have chosen makes it feasible to approach the problem of creating a sharp chronology for Pacific prehistory based on ancient genealogies and associated traditions. The Pacific has a limited artefact array, which in many cases is not readily datable. Climate data and awareness of the oceanographic factors governing migration, in combination with genealogical analysis, enrich the study of traditional histories and make sketching a chronology a realizable goal.

In Chapter 20 we consider the phenomenon of low Maori genetic diversity, the lowest of almost any people on the planet. This leads us to a new interpretation of Maori genetic history which offers support for our arguments for a Lapita-age first-wave Spice Island settlement of New Zealand and for a long early isolation. It also supports the likelihood of very early events in Maori prehistory suggested by Moriori tradition and especially of a near-extinction event 17 generations after first settlement. The genetic predominance of an ancient Lapita-age Spice Island genetic inheritance for Maori can be demonstrated mathematically. It strengthens our interpretation of New Zealand's singular place in our wider history of the peopling of the Pacific.

The chronology we sketch for Polynesian and Maori prehistory casts light on the general history of the exploration and colonization of the Pacific. It supports a history that ranges from the colonization of Micronesia from the Spice Islands nearly 6,000 years ago to the Lapita colonization of the Bismarcks and Solomons 1,500 years later; from the very early settlements of New Zealand and the Chatham Islands to the first and later colonizations of Hawaii and of Japan; from the southern migrations to Hawaii in AD 1096 to the multiple migrations from Eastern Polynesia to New Zealand in the same global climate period.

The sequence of events is clarified, the role of climate in driving demography and migration illustrated. The prehistory of New Zealand is taken from a limited, late, local archaeological context and placed in an earlier wider oceanographic context. Its place in that context transforms the way we see its prehistory and palaeodemography. New Zealand acquires a radically new chronology, a new place in the history of the peopling of the Pacific. It recovers the long prehistory recorded for it in Maori tradition. And it gains a new climate-driven demography that leads to a very different reading of its history in the Little Ice Age and to a new understanding of the 7,000 pa built in that period.

We have attempted in our book to draw on an extended range of scientific evidence relevant to the study of Pacific prehistory and to encourage a flexibility of approach by combining scientific insights with traditional knowledge. With a Spice Island and West Pacific Warm Pool base, the powerful role of oceanography in determining the evolution of exploration, trading and migration in two oceans becomes clear. We are able to explain how and why the last lands on the planet to be colonized were settled by a single people with a unique genetic heritage speaking dialects of a single language, who were the inheritors of an ancient maritime trading culture. The Spice Islanders' genetic and maritime evolution are tied both to the oceanographic history of the West Pacific Warm Pool and to their possession of unique spices. The economic motivation of horticultural trading is seen as a persistent driving force in their genetic and maritime development We stress the importance of the geographical position of the Spice Islands (lying at the edge or within the West Pacific Warm Pool, poised between two oceans and two biological zones) in shaping the Spice Island's horticultural trading history. And our analysis is presented in a context of global climate change that gives it additional coherence, validity and relevance. We set our version of Maori prehistory during the Little Ice Age, for example, in the context of catastrophic population losses worldwide and suggest that, to be properly understood, the whole history of the settlement of the Pacific has to be read in the light of global climate history. The global climate context we evoke enables the oceanic prehistory we unfold to be seen not as isolated and idiosyncratic but as part of global history.

We have shown some of the ways in which insight and historical information can be gleaned from traditional sources. But one cannot discount the difficulties that are sometimes involved. The catastrophic population losses during the Little Ice Age in both New Zealand and in tropical Polynesia, the probable extinction of indigenous tribes possessing the oldest histories and the cultural shock and near-fatal impact of European contact throughout the Pacific must have led to a vast loss of traditional knowledge. Contradictions and difficulties in interpreting traditional knowledge are hardly surprising in these circumstances for often we may be working with a confused subset of knowledge. Yet to dismiss traditional knowledge as "mere myth" is to lose the valuable insights that can sometimes be gained, especially now when events recorded in traditional histories can be examined anew in the light of modern climate proxy data capable of dating events with more precision than radiocarbon analysis. The value of the few long carefully preserved genealogies we have studied is apparent: their value as historical sources enhanced by the precision of high-resolution climate proxy dating.

Over a range of contexts the interface between traditional knowledge and modern scientific research provides exciting possibilities for unravelling ancient history from tradition. We have shown, for example, how the demographic information implicit in two ancient genealogies preserved in the isolation of the Chatham Islands, read in the context of global climate history and of the documented survival problems of small isolated populations, makes it possible to reconstruct the early history of Lapita-age Spice Island migrants in New Zealand, to date their arrival, to posit the likelihood of a near-extinction event, to suggest its date and possible cause and to sensibly explain the extraordinarily low genetic diversity of modern Maori.

Modern statistics helps decode from skeletal data evidence of extreme population losses in the Little Ice Age. A power law approach can decode new demographic information implicit in New Zealand's 7,000 hill-forts. Studying pa in the light of falling populations leads to a quite different reading of their fortification history.

Modern climate research enables us to read the migration history of the central and eastern Pacific from the timing of extreme El Niño events triggering drought, famine and associated conflict over land and resources. The same research enables us to understand the demographic history of New Zealand Maori. And recurrent patterns of intense El Niño events help us to date the activities of a line of famous navigators in Eastern Polynesia during the Medieval Climatic Optimum and to suggest dating for some early migrations to New Zealand. The Huguang Maar climate proxy data confirms the genealogical dating inherent in two rare Moriori genealogies.

This book has been driven by our sense of exciting possibilities for illuminating prehistory by combining scientific and traditional contexts to reclaim some of the power and relevance of oral traditions. It is in traditional histories that we meet some of the individuals who shaped Pacific prehistory. Their personalities and deeds, made vivid in story, give a richness to tradition that a prehistory with a limited artefactual base simply cannot match.

The archaeologist literally seeks material evidence and when he finds none may assume there is none. Evidence trails are often subtle and implicit. In New Zealand perhaps even archaeological evidence has to be approached with some subtlety. The finding of a Lapita rat haplogroup at Palliser Bay, for example, the early settlement where, tradition tells us, Maui met the chieftainess of Orokoroko, can be seen, not as an anomaly that cannot be accounted for, but as evidence for a Lapita-age rat introduction into New Zealand. This creates in turn a context in which Richard Holdaway's 1,800-year-old fossil rat is more explicable, as is the unique New Zealand mutation of the ancient Lapita rat haplotype that was found at Palliser Bay.

A consilience of evidence confronts the late settlement theorist. In the light of our paradigm and of evidence from global climate history for a 600-year early total isolation for New Zealand 400 years after first settlement, the account of Maui's visit to New Zealand has historic resonance. In Chapter 3 we considered evidence for the presence in New Zealand of the Japanese taro, better suited to higher latitudes than the tropical varieties found in Eastern Polynesia (where the Japanese taro is not found). Hendy's evidence that the New Zealand form underwent a mutation

2,000–3,000 years ago is of a piece with evidence for the presence of a Lapita-age rat haplotype in Palliser Bay which also appears to have undergone a unique mutation, apparently after its introduction to New Zealand. Additionally, the possibility that four out of nine Maori haplotypes may have come into existence through independent mutation in New Zealand adds confirmation to our claim for a long human history in New Zealand.

In writing a Polynesian prehistory with a Spice Island and an oceanographic base, we have called on evidence from many domains to explore new possibilities. The consilience of explicit and implicit evidence, obvious and subtle, that we have sought to weave together in this book cannot all be expected to have the rigour of scientific certainty, for history is as much an art as a science. Yet, as we have shown, science can provide strong evidence bases for free and widely ranging analysis. An oceanographic evidence base, for example, opens up possibilities never explored before, though it possesses striking implications for understanding and dating events in the earliest phase in the peopling of the Pacific. It possesses striking implications too when it comes to defining trading and migration paths followed for 2,000 years in the Pacific and Indian Oceans. Traditional histories record events matching possibilities inherent in our central paradigm, which can sometimes be dated precisely from climate proxy data. This supports our case for adopting a broader, more inclusive approach. We have indeed sought to create a tapestry woven of suggestion and inference, to combine scientific evidence, the power of traditional narrative, mathematical certainties and imaginative speculation. One purpose of this book will be achieved if the reader recognizes the compelling power of an oceanographic focus for Polynesian prehistory linked to the West Pacific Warm Pool and its strong major currents. Another if the reader acknowledges a powerful second focus in climate history. We hope we have encouraged open-mindedness, a willingness to look below the surface for implicit evidence, to consider new contexts in which to understand old evidence and to listen to what traditional histories can teach us.

Appendix
Genealogies

Moriori Genealogy

Heaven and earth were pushed apart by Rangi-tokona (the Sky-propper), and heaven and earth were separated – their children were born. [The first thirty names on this list record the heaven-born (Te whanau-o-te-Rangi). The last eight of these are said to be female.]

	Tu
	Rongo
	Tane
	Tangaroa
5	Rongomai
	Kahukura
	Tiki
	Ngangana
10	Io
	Iorangi
	Waiorangi
	Tahu
	Moko
15	Maroro
	Wakehau
	Tiki
	Toi
	Rauru
20	Whatonga
	Rongomai
	Kahukura
	Ruanuku
	Motu-ariki
25	Te Ao-marama
	Tumare
	Ranganuku
	Matariki
	Wari
30	Tauira

C.E.M. Pearce, F.M. Pearce, *Oceanic Migration*,
DOI 10.1007/978-90-481-3826-5,

Tokoroa
Tokopoto
Tokomahuta
Tokomauhara
35 Rupipi
Ruwaruwaru
Rukuhautai
Rukuwhakapeka
Ruhitioro
40 Tamaariki
Tamamutu
Rangipoutu
Ranginaonao
Rangituwehi
45 Tiki-mata-wha
Tumanukura
Rongohua
Tangaroa-matahi
Uhenga
50 Papararo
Tangaroa-whatu-moana
Tamanui-te-Ra
Tamahiwa
Te Hiwarangi
55 Rongomai
Kahukura
Te Ao-marama

Rongomaiwhenua*

	Tamahiwaki	**Maikoua**
	Nuku-o-wae-roroa	Rangipokia
60	Tutawake	Turangi
	Turanga-mamaoa	Rangitakohu
	Ngake	Tamoe
	Pehe	Ripo
	Tu-ta-upoko-o-Rekohua	Tangaroa-mapuna-wai
65	Tumakao	Tongonui
	Tuwatawata	Heu (Hau)
	Hariunga	Roa
	Papa	Waka
	Toromatua	Tapopohewa
70	Takare	More
	Hawaikie	Takitumu
	Tutohia	Tumunui
	Hokotaka	Rakaraka
	Wharekaraka	Hamuru-tonga (atua)
75	Rangitipi	Hawaitauru
	Maituporo	Marukaputu
	Motorea	Taputo-ao

	Huturere	Tamawharou
	Tu-te-rangi-marama*	Kai-toro
80	Te-Ao-maira	Tapongi
	Tairi	Rotoru
	Tarere	Moputehi
	Manu-kau-moana	Waikawa
	Kahu-ti*	Torohanga
85	Tatitiri	Tamaturoa
	Korongo	Tamakautara*
	Poke	Tapu-toro
	Kohiroa	Poutarau
	Ana	Rongomai-to-whatu-ma
90	Apata	Wairere
	Tohenga-aitu	Kahutua
	Hamatua	Rangihikimeo
	Ta-ta-roa	Tama-ngutu-ao
	Puwiwi	Wharemai
95	Wairewa	Tama-ngutu-ure
	Tangaroa-kuau	Kairoro
	Tauira	Tumuririko
	Toko-tea-rangi	Tumurarapa
	Tukoai	Parawhenuamea
100	Hapaikato	Ta Upoko-papa
	Kahukare	Rangitahia
	Tauaru-kura	Tuwahine
	Rangituake	Tahiwata (atua)
	Maititi	Rutake-whenua
105	Wakiri	Tuwakehau
	Te Ikaroa	Rangi-wahia
	Manapupu	Rangi-ka-matata
	Tarewa	Tuwahia
	Ruaouru	Mahutu-ata
110	Rongomehori	Matowha
	Tumakao	Potiki-tehi
	Kie	Kaumoana
	Tuwatawata	Tama-tahuri
	Aoroa	Tutohia
115	Tukoia	Poroa
	Tuatahi	Mokeao
	Marupinui	Tuwakehau
	Maunga	Tami-ripo
	Kueo	Wai-tongo
120	Painui	Ririhorea
	Tamakikihi	Mokara
	Tapepeke	Poretu
	Tihauwanu	Te Rikitahatika
	Karangatua	Tamatahatu
125	Whatonga	Manawatahia
	Tawahine	Tamatakuao
	Kautore	Wharewi
	Mana-aotea	Wharekura
	Apunui	Tama-hokototoro
130	Takaro	Te Awapuhi

Tamahitita
Raumati
Ngana
Karewa
135 Taheke
Rapaki
Hamuroro
Tatitiri
Pounamu
140 Kueau
Mano
Kaimurumuru
Tohoanga
Tuneinei
145 Tuapaka
Tuarare
Rangitipi
Taihakama
Waka-ariki
150 Wakatukou
Eha
Marama
Ika
Tauanunuku
155 Tamohewa
Kaiuaua
Rongopapa*
Tamutu
Piriake
160 Tamehe
Tapanga
Tutoake
Manapo
Tuwetenga
165 Romgomai-a-kura
Moriro
Pakaurua
Hupe
Hapekirehe
170 Tamakahe
Tamakanoi
Rangimene
Tapumata
Waitahe
175 Te-Riki-toroa
Te Ika
Tamatuahu
Tapongi
Tama-karanga-po
180 Manu-kapua
Tama-te-hokopa
Tamahiwaki* - The reciter, and
Three generations now living

Rangiwera
Tehuaimi-ro
Te Auriri
Te Au-nguiha
Titire
Manaonao
Tu-toko-tapu
Pa-okooho
Tapuhautere
Matirawhe (a bird)
Tangaro-pouri
Tangaro-potango
Mawharu
Whare-tangata
Tapeneke
Tamakopupu
Tamatoke
Tamakororo
Turumoe
Tuhoe
Tangiwharau
Tamaroroki
Herepo
Hitauira
Marumama-ke
Marupuku*
Tana-hokorere-kura (f)
Tana-mairewa (f)
Te Au-ripo
Te Au-mate
Tupuwhenua
Hinewao (f)
Tapihanga
Rongo-rau-eruhe
Turori
Tuiti
Tane
Tapito
Hinepango (f)
Hinewere (f)
Pere(e)-wao
Momotu
Hine-kokomuka (f)
Manawa-take
Manawa-huka
Tapoukore
Wai-tamui
Te Akepiri
Koenga-punga
Hine-anaukahu (
Hine-anau-kahu (f)
Hituaro
Puatou

(the third are children)

Maitokehanga
Hawea
Ta Ihi
Te Rikimohewa
Puangaiho
Maihoua 185

Source: Shand A (1911) The moriori people of the chatham Islands: Their traditions and history. Vol. II, Memoirs of the Polynesian Society, Wellington

The Main Rarotongan Line

Te Tumu=Papa (f)
Te Nga-taito-ariki 2 Atea, 3 Te Tupua-nui-o-Avaiki 4 Pupu 5 Ku-kura
(lived in Atia-Te-Varinga-nui or Availi-Te-Varinga-Nui)

Mua — Tu-te-rangi-marama
Eanga
Maina
Maeata
85 Makaro
Te Marama
Te Eanga-ki-te-ao
Tangata-kato
Te Atu-tanganga
80 Te Atu-te-ngatata
Te Atu-te-ki
Te Atu
Tiki
Taito-rangi-ngunguru
75 Taito-rangi-ioio
Taito-kuru-angiangi
Taito-kuru-ma-rakamea
Vai-takere

Te Tarava — Ina=Maui-tikitiki
70 Te Tarava-enua
Te Rua-enua
Rua-mata-iko
Ara-kapua, 2 Punupunu, 3 Uta-rei
Te Ara-o-nga-atua
65 Toi
Punga-verevere
Manu
Manu-kaiaia
Manu-kavakevake

60 Ore
Turanga Ruru
Rongo-rua
Rira
Te Ira-panga
55 Tu-tarangi
Etoi
Etai
Emaunga
Erangi
50 Ui-tamua
Ui-taringa
Ui-te-rangi-ora
Te Rangi
Ata-o-te-rangi
45 Tara-o-te-rangi
Te Paku-o-te-rangi
Te Uka-o-te-rangi
Uu
Ane
40 Taipu
Tuna-ariki (contemporary with 1 Tu-ei-puku, 2 Maru)
Kati-ongia
Kapua
Atonga (ct. Rata)
35 Te Arutanga-a-nuku
Te Arutanga-a-rangi
Te Amaru-ariki
Te Amaru-enua
Te Uenga-ariki
30 Te Uenga-enua
Kau-tea
Kau-mango
Vai-iti
Kau-kura (Kahukura*)

25 Pou-vananga-roa (Maru*) Kau-ngaki

Tangiia-nui*
Motoro

Uenuku-rakei-ora 2 Tane-here-pi
Uenuku-te-aitu*

20 1 Paikea Ruatapu

Source: Communicated to S. Percy Smith by Te Ariki Tara ‘Are, the last high priest of Rarotonga, whose training predated the arrival of Europeans. Recorded in Smith’s (1904) Hawaiki, the original home of the Maori. 2nd edn, Whitcombe and Tombs, Christchurch

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